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THE
Chicago Academy of Sciences

THE LICHEN-FLORA

OF

CHICAGO AND VICINITY

BY

WILLIAM WIRT CALKINS

BULLETIN No. 1

OF THE

Geological and Natural History Survey

ISSUED APRIL, 1896

THE

Chicago Academy of Sciences

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LETTER OF TRANSMITTAL.

CHICAGO, ILLINOIS, April 1st, 1896.

DEAR SIR:

By direction of the Board of Managers of the Geological and Natural History Survey ot The Chicago Academy of Sciences, I herewith submit to you the report on The Lichen-Flora of Chicago and Vicinity, prepared by William Wirt Calkins, for publication as Bulletin No. 1 of the Survey, to be issued under the rules of the Academy governing such matters.

Respectfully,

C. M. HIGGINSON,
Pres't of The Academy of Sciences.

WILLIAM K. HIGLEY,
Chairman.

The Board of Managers of the Geological and Natural History Survey of The Chicago Academy of Sciences:

WILLIAM K. HIGLEY, Chairman.

CHARLES S. RADDIN, Secretary.

GAYTON A. DOUGLASS.

WILLIAM E. LONGLEY.

THOMAS L. JOHNSTON.

THE GEOLOGICAL SURVEY.

The Bulletin on the Lichen-Flora is the initial number of a series of publications in which the Geological and Natural History Survey of the Chicago Academy of Sciences proposes to discuss the plants, animals and geological formations found in the vicinity of Chicago. In this first issue it may be well to briefly outline the history and state the objects and aims of the survey.

On the 10th day of May, 1892, the Academy of Sciences unanimously adopted the recommendation of its Executive Board that a committee of three be appointed from its active membership to conduct a topographical survey of Chicago and vicinity. At the June meeting of 1892 the Academy adopted the recommendation of this committee to enlarge the scope of the work so as to embrace the natural history of the region; the work to be known as the Geological and Natural History Survey of the Chicago Academy of Sciences. Three general departments were decided upon: Geology and allied sciences, Topography, Zoology and Botany. It was further decided that the work in the several divisions of these departments should be entrusted to men recognized as specialists, and published as bulletins and reports, which should be as nearly monographic as possible.

Since the organization of the survey, the work has been steadily progressing, and a large amount of data has been collected. It is eminently fitting that before studying the rocks and higher forms of vegetable life, the lichens should be taken from the boulders and the bark and made the subject of the first issue.

The survey comprises a labor both of economic and scientific value. The publications on geology and topography are awaited with great interest by contractors, engineers and scientific men generally. The co operation of practical men in the preparation of these reports has been spontaneous and very general. It is proposed to show the character of the rock strata underlying our area, their distance from the surface in different localities, the nature of the materials resting on the rock, the depth necessary to reach water, and such general information as will assist builders, well-borers and engineers in the prosecution of their professions. With this will be reports on the geological formations, their origins, extent and relations to the present condition of affairs in Chicago and vicinity. There are many features of our local fauna and flora

which are either unfamiliar or unknown to the majority of the people. Hence to place reliable reports on these subjects in the hand of older workers and beginners, of educators and students, is not only to increase facilities for information, but to awaken interest and stimulate investigation.

The area covered by the survey is peculiar in two distinct systems of drainage, either of which may, under certain conditions, prevail over the other. This peculiarity of the drainage is of great scientific interest. To bring out this relief it was thought desirable to fix upon the following boundaries: Beginning at the north line of Cook County and Lake Michigan, thence westward, coincident with the north line of Cook County to Kane County; thence southward along the east line of Kane and Kendall Counties to the southeast corner of Kendall County; thence eastward, coincident with the south line of Cook County to the east line of Lake County, Indiana; thence northward to Lake Michigan.

This gives an area of about forty-eight or fifty miles square, which, after deducting the approximate area of the lake-covered portions, leaves nearly eighteen hundred square miles of land surface. It comprises all of Cook and DuPage Counties, the nine north townships of Will County and a portion of Lake County, Indiana. Of the proposed reports now in preparation, a list of which may be found elsewhere, many will be illustrated and some will describe species. All will give such notes and information as will be of scientific interest.

It will be the aim of the Board of Managers of the survey to have specimens in the Academy collection illustrating the local rocks, minerals, fossils, animals and plants enumerated in the reports. This will enable the student to compare and study the objects and not have to depend solely on descriptions.

The first BULLETIN, on the Lichens, is of especial value, because the field is practically new in our vicinity. Few of our local botanists have directed their attention to this class of plants. Mr. Calkins has deposited a complete collection of local lichens in the Herbarium of the Academy building, and it is hoped that the BULLETIN, together with the specimens, will develop interest and investigation in this form of plant life, and lead to the discovery of many new species and localities. It is desired that all who are interested in the advancement of science will co-operate with the Board of Managers by furnishing any data within their reach.

The Lichen-Flora of Chicago and Vicinity.

William Wirt Calkins.

INTRODUCTION.

The following report, based upon my personal investigations, collections and studies, during a period of many years, has been prepared by invitation of the Board of Managers of the Geological and Natural History Survey of The Chicago Academy of Sciences.

As directed by the Board the report covers an area comprising all of Cook and Du Page Counties, nine townships in the northwest part of Will County, and a portion of Lake County, Indiana. This territory might be thought sufficiently large to furnish an attractive field and ample material for the investigation and study of lichens, yet with the exception of the most common species, a few of which are cosmopolitan in their habits, the explorer will meet with a disappointment not to be experienced further south and west in regions where the conditions of the soil, the geological features of the country, and the climate favor a larger development of species. Hence mountainous districts and the extreme South offer the greatest variety of forms, those of Florida being largely semi-tropical and identical with West Indian and Central American species, especially in certain genera, as Graphis and Arthonia. However, in the field under our consideration, enough varieties occur to form an excellent preliminary course of study, fitting the student for larger views and greater results when he has become familiar with the Parmelias and Physcias which are so abundant on oaks and other trees along the lake shore and in the "wooded islands of the prairies."

The geological conditions in most of our territory are not favorable to the growth of a great number of species owing to the absence of forests and out-cropping rocks of different formations and ages, all having an important bearing, because these are the substrates to which lichens attach themselves, and the investigator will note at once that certain strata and trees, or the earth, contain some species not found elsewhere, while others are indifferent as to substrate. Localities in and around Chicago formerly rich in lichenose vegetation are now destitute of it. The species were and are mostly corticolous, with a few on rocks, where exposed, and even on the boulders of our prairies. But the tidal waves of civilization have changed the conditions under which lichens grow, and to find them abundantly we must seek the country where the air on which they feed is pure and the substrates suitable. The sandy soil of the lake shore only produces them where it is covered or mixed with vegetable mould. Northwards from the limits of Chicago the genera Cladonia and Peltigera are found in the woods on earth. The scarce growth of Birch (Betula papyracea), near Glencoe, contains two species rare in this section. These are Sagedia oxyspora, Tuckerm. and Pyrenula thelæna, Tuckerm. The former is peculiar to that substrate. On trees, notably the oaks, are abundant growths of Parmelia borreri, Turner, P. caperata, (L.) Ach., Physcia stellaris, L., Lecanora subfusca, Ach.; and on hickory, Arthonia lecideella, Nyl. The latter is peculiar to this substrate and the genus rare, in our territory, in species, although the above and A. spectabilis, Fl., are abundant. Leaving the vicinity of the lake and the flat-prairies, we find further west and south the best development of lichen-flora along wooded streams and on rocks where these are exposed. Gravel, boulders, old fences, logs and stumps, sustain many species. New and rare ones sometimes reward the explorer. At Riverside I found a new Verrucaria on siliceous deposits and at Joliet, another new species, Lecanora perproxima, Nyl., on silurian rocks. Both have been described by Dr. Nylander, of Paris. The saxicolous species are the most difficult and many are in confusion. The occupation and use of nearly all the lands; the denudation of forests, and drainage of the country, has, as in the case of the phænogamia, caused many species to disappear entirely from our territory. The best localities for saxicolous types are in the township of Lemont and Will County. Hanover and other places adjacent to streams produce common forms. A few occur on earth

and on mosses, which are minute and easily escape detection. On calcareous soils in Lemont, also in Will County, may be found, besides Cladonia, the curious Heppia despreauxii, Tuckerm. and several species of Endocarpon; also a member of the Algæ Nostoc commune, L. The close association of these species, which I have witnessed in other States on similar strata, is worthy of note. From what has been said it appears that it is not safe to fix definitely the number or limits of species in any territory, at this early date of scientific research. The experience of the author, resulting in the addition of nearly thirty new species of lichens to botanical science, is proof of the fact that there are still hundreds of species yet undiscovered.

Some eight years ago Willey estimated that the whole number of North American species might ultimately reach one thousand, but that limit has been passed already, as I have the names of over sixteen hundred, including varieties, and it is not at all probable that, after the most conservative study and elimination, the number would be reduced by more than three hundred, if so many.

Having now reviewed in a general way the lichen-flora of the territory under consideration, it seems proper, as nothing has ever been published in the West and South regarding Lichens, beyond mere lists of species, that something should be said about the life history of these humble plants, and of the study, development and progress of the Science of Lichenology, especially in the United States. The account must necessarily be condensed, but it is believed will be of great utility.

WHAT ARE LICHENS?

This very natural and primary question may be thus answered: Lichens are a natural order of aerial plants which are considered as intermediate between Algæ and Fungi, but the limits are still uncertain. All are Thallophytes destitute of stem, leaf, root, or flower, and vegetate under the influence of moisture, obtaining the elements necessary to their growth from the air, and not from their substrates, as do the Fungi. Consequently lichens are rapid or slow in growth according to the conditions surrounding them. In extreme heat they become torpid, or do not fully develop, frequently appearing on the surface of their substrates as excrescences, wart-

like or coralloid. This condition gave rise to the pseudo-genus Lepraria, Isidium, etc., not now recognized. Lichens may grow for a century or more, and under poor surroundings increase by bisection, like Algæ. They will be found under these conditions near towns and cities, where the air is not pure.

The thallus and the apothecium, or fruit, are the parts of the plant to first attract attention in the higher lichens—for example, the Parmelias, so common on our oaks. The thallus is attached to its substrate by fibrils, or is subcortical, but is absent in certain species, as the parasitic ones.

In the thallus are green cells called gonidia, and other organs, as spermogonia and pycnidia. Dr. T. M. Fries constructed a system based on the gonidia, which are variously formed and colored. The thallus supports the apothecium, which is the most important part of the plant. This appears on the surface, disk-like, lirellate, etc., and of several colors, such as red, orange, black or brown. In some genera the fruit appears as minute, wart-like bodies, with only a pore (ostiole- at the summit. In others, as Cladonia, the fruit is at the end of thalline stalks (podetia), or as in Cetraria, on the edges of the thallus. There are, however, various modifications of all these. One peculiarity of some lichens is the power they have to burrow into the hardest rocks, even flint and granite, thus making for themselves homes (foveoli). The power is furnished by the carbonic acid absorbed from the air. As an example, Verrucaria ruderella, Nyl., from the limestones of La Salle county, Ill., may be mentioned. The apothecium contains the germinating cells, or spores, which are inclosed in sacks, called thekes. There are many organs, all of which must be examined under the microscope, and these have been the subject of profound study and discussion many years, but especially since the microscope came into use. On them many fanciful theories as to the origin of lichens, whether they are autonomous or not, have been built. Fries called them aerial algæ. Schwendener gives his views as follows, which seems marvelous, if true: "All these plants are not individuals in the common sense of the term; they are rather colonies, consisting of hundreds of thousands of individuals, of which one holds the mastership, while the others, in eternal captivity, prepare the nourishment for themselves and their master. The master is a Fungus of the class of Ascomycetæ, a parasite which lives on the labor of

others. It encloses them as a spider its prey, with a network of delicate tissue, which is gradually transformed into an impervious integument. But while the spider sucks the life out of its prey, the Fungus stimulates the algæ in its grasp to greater activity, to a more vigorous increase, and thereby renders possible a more luxurious growth, and promotes the welfare of the whole colony." *

However grand the Schwendener theory, the question of autonomy is still open, while new discoveries are being made which may eventually change the whole aspect of the science. Our best way now is to effect their classification under the present system as elucidated by Tuckerman, but not ignoring others entirely.

The student seeking to become acquainted with lichens will soon learn to distinguish those highest in the scale, as Parmelia and Physcia, in our vicinity, by the prominent, foliaceous thallus, and apothecium, and having fixed the external character in his mind, will soon associate with them others of similar appearance, yet differing to some extent in thallus and fruit. In the same manner he will identify and bring together species of other genera, and perhaps stumbling on forms of Lecanora and Pyrenula, lower in the scale, observe the characters that seem prominent and common to all. Experience will enable him to determine very many of our common species from external characters alone, as indeed, the early lichenologists determined them all, even up to the time of Webber and Acharius.

THE DIVISIONS OF LICHENS.

All our lichens may be placed in one of the two series into which they are divided by the fruit. First, the Gymnocarpi, those with open fruit; second, the Angiocarpi, those with closed fruit Pyrenocarpous). There are five tribes, Parmeliacei, Lecideacei, Graphidacei, Caliciacei, Verrucariacei. Only the last belongs to the second series. The tribes are based on the apothecia; families on the thallus and fruit. Genera and species follow. Other subdivisions are made for convenience, and sometimes at the caprice of authors.

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* *Die Algentypn Flechtengonidien.*

THE THALLUS AND APOTHECIUM—SOME OF THEIR ORGANS.

The thallus, when present, and the apothecium, are to be considered and studied externally, but the organs of the plant must be examined with the microscope. Some of these have been mentioned, and I can only refer briefly to others, doing so in order to guide the first steps of the explorer, who, at every advance, will meet with new problems and find all aids necessary. In examination, the membraneous thallus, cut in a thin section, will show above what is known as the cortical layer of minute aggregated cellules; next, the gonidial layer of green cells; then will follow compacted filaments (hyphæ), and in this formation rest the gonidia. Below is the inferior cortical layer, from which, in many species, proceed fibrils (hypothallus), attaching the plant to its substrace. Some lichens, such as the parasitic, and some others, Peltigera and Collema, have no thallus; either the upper or lower cortical layer may be absent, or but one scantily represented. The gonidial and other wart-like eruptions sometimes appearing on the crust (soredia), constituted the basis of the old pseudo-genera. The color of the thallus above and below may differ, as in Sticta. The gonidia of divers forms and colors are variously placed, singly or grouped, or of confervæ-like character.*

The apothecium, which has been slightly noticed, whatever its shape, has a uniformity of internal structure. The disk-epithecium, (exciple), contains the other organs, and is enclosed by a margin, which may be formed from the thallus (thalline margin). It is then known as lecanorine. When the margin or border is not thalline the apothecium is lecideine. Then there is the nuceliform apothecium of angiocarpous lichens. The exciple, when colored or blackened, is biatorine; when composite, zeorine. Grouped apothecia form a stroma. The perithecium and amphithecium of the angiocarpous lichens are the outer and inner coverings; within is the nucleus. A section of the apothecium viewed under the lens, shows the epithecium to be of colored, granular matter and borne on the apices of what are termed the paraphyses—slender filaments growing from the medullary layer. The apices are globular or clavate. The thalline exciple containing gonidia, and the hymenium, bearing the thekes, within which are the spores, will be seen. The hymenium is either colored or

*Th. M. Fries, Dr. Minks and others as to their systematic value.

colorless. The thekes vary in shape, linear, clavate, etc., and are large or small, according to the spores. The latter are variable in form, size and color, as well as in number; they are either simple or divided by transverse septa into cells, usually eight, when they are called eight-locular; if more, pluri or multi localar, but there may be less. When it is also divided longitudinally it is called a muriform spore. The examiner will often find no spores, hence should have fresh plants, particularly of Arthonia. The spore may be less than a thousandth of a millimetre in diameter, but some can be seen with an ordinary lens. Much importance is attached to the colors and shape of the spores. Spermagones have been mentioned. These will exhibit, arising from them, small filaments, which if simple are called sterigmata; if articulate, arthrosterigmata, to which are attached minute bodies (spermatia) which are various in form. Nylander, Minks and others have theorized and written learnedly in regard to their functions.

It would be desirable to explain further in regard to the spores and other organs entering into lichens, but these can be studied to better advantage after one has acquired some knowledge of the more obvious characters, besides no one can do much with any satisfaction until he has studied our greatest American authority, Tuckerman, and with his works those of the great Lichenologists of Europe, a few of whom are mentioned hereafter. Armed with these, a genuine love and adaptability, success is assured up to a limit, for it is not probable that all the secret processes of nature can be wrested from her grasp by even the greatest minds in a single lifetime.

THE DEVELOPMENT AND PROGRESS OF THE SCIENCE OF LICHENOLOGY.

The study of lichens was for many years, on account of its supposed difficulties, confined in this country to a very few persons, who lived remote from each other. Thus it has a scattered and little known literature, which, however meager in quantity and quality (with the exception of the works of Tuckerman and Willey), has proved almost inaccessible to students, or those who otherwise would have become interested in a branch of botany now assuming more importance among American students. There were, also, other reasons why so few botanists pursued the study. Until the late Professor Edward Tuckerman published his great works upon American Lichens, the results of a life-time of devoted labor,

there was not in the United States any lichenological literature worthy of the name; no system of classification of American origin, under which our vast and rich lichen-flora could be arranged. Students were dependent entirely upon the works of Euporean authors, and these were mostly in foreign languages not easily to be obtained or understood here, except by the very few, who, like Tuckerman, lived under the shadow of a great university and had a liberal education. Thus it was that New England almost wholly absorbed the study of this branch of science. Also, every European lichenologist had a system of his own, and no two could agree on a uniform method of classification applicable to the species known and the many new forms being constantly discovered.

In ancient times nothing was known of lichens as a distinct order of plants, but one or two species have been found in coffins, no doubt used for padding. A reference to the old herbalists of the twelfth and fifteenth centuries show that lichens then went under the names of "fuscus" or "muscus," and were considered allied to the mosses. They began to attract more attention in the sixteenth century, and over twenty species were described. The general revival of all learning after the dark, middle ages, stimulated the study of botany, and lichens shared in the benefit. It was then that Tournefort separated them from the musci, and included all then known under the general name, Lichens. This distinctive term was accepted and used by the great Linnaeus. From sixteen hundred to the Acharian period, about 1802, rapid progress was made in the study. During this period lived Micheli, Webber, Dillenius, of Oxford, Hoffman, Linnæus and Acharius, the "Father of Lichenology." All these were celebrated for their learning and published works upon lichens. Over three hundred species became known up to 1750, and were arranged in natural groups and genera, many of which still stand. Their chemistry and economic uses were studied, and collections of lichens made. But the best thoughts of investigators in the latter part of the eighteenth and the first years of the nineteenth century found a truer expression at last in 1803, when Acharius published the result of his studies in the Methodus Lichenum, followed in 1810 by his Lichenographia Universalis, and in 1814 by the Synopsis Lichenum. These gave full accounts of all the then known species, over nine hundred. A number of American species are mentioned.

He made no use of the spores and thekes in his classification. The system he founded was long used and made his name immortal. In 1831, Elias Fries, the great Swedish botanist, published the Lichenographia Europea Reformata, and gave utterance to views that have influenced all later studies of the greatest students of lichens. He divided them into eight tribes, of which five now stand as given elsewhere. He also made further divisions which subsequent writers changed or assumed. The views of Fries were so far in advance of others and his work as a systematist so highly regarded, that Tuckerman referring to the advances made in the study of lichens, says: "The whole movement took its start from the results gained by the unsurpassed penetration of Elias Fries."

But the period was a golden one and prolific of eminent botanists—Nylander, Eschweiler, Fee, Wallroth, Schaerer, Montagne and Floerke, all systematists. There were also many others of great eminence in Lichenology. Of the above Dr. William Nylander, who still survives, is the most celebrated. He has not only published many philosophic papers and works, but has described more new species than any other man, and his knowledge of lichens exceeds that of all others. Dr. J. Muller is hardly less distinguished, however, while Dr. Minks, and Schwendener, have achieved renown by wonderful discoveries as to the anatomy and growth of lichens, which, if they are confirmed, will overturn all previous theories. From what has been stated it will be seen that Europe had monopolized the field of study, and naturally enough, for America was young.

It was at such a time that Tuckerman, who had turned early to the investigation of lichens, became an earnest student of the great European botanists, particularly of Acharius, Fries and Nylander. Assisted in the field by several enthusiastic workers, portions of New England were explored and the lichen-flora studied and made known to the world. As his views enlarged he gradually came to have conclusions of his own as to the systematic arrangement of the species in harmonious and natural relations with each other. The great Swede seems to have been his guide in part, while Nylander was not disregarded, nor in later years the new discoveries of Minks, Tulasne, Bayerhoffer and others. Tuckerman was pre-eminent as a systematist, and the full elucidation of his views will be found in his works—The Lichens of California, 1866; General Lichenum, 1872; and his Synopsis,

Part I., 1882. A close study of these will show how very near he came to nature in his reading of her laws as applied to the lichens, and how well he succeeded when he came to their arrangement. The key to his success may be found in his expression—"Apprehension of the Habit of Lichens." This was certainly an inspired faculty and led him to forecast the relations of lichens by which they could be placed in the system he established, as Tribes, Families, Groups, Genera, Species, etc. The one great American Lichenologist is dead, but the services performed cannot be overestimated. Part II. of his Synopsis, left incomplete at his death, which occurred March 15, 1886, was edited and published by Henry Willey, Tuckerman's life-long collaborator, in 1888. The foregoing were by no means all of Tuckerman's works, but they are the most important, on which rests the solid basis of his fame. As a supplement to the labors of Tuckerman, American Lichenology has been benefitted by Henry Willey, in his publication, "Synopsis of the Genus Arthonia," and his introduction to the "Study of Lichens," but these must be considered rather as aids to be used in connection with the study of other authors. While the publications mentioned are the chief ones in this country, monographs upon a single genus, or species, have appeared from time to time; also local lists and brief papers, and these evince the interest awakened, which no doubt received its impelling force from a knowledge of the genius and labors of Tuckerman.

THE ECONOMIC USES OF LICHENS.

A few remarks on this subject will show how large a part these seemingly humble plants play in the economy of life. The Reindeer Moss (Cladonia rangiferina) furnishes not only food for the reindeer in the Arctic regions, but alcohol and brandy are distilled from it by the natives of Norway, Sweden and other countries. The Iceland Moss (Cetraria Islandica) has long been in use, both for food and medicine. Cetraria nivalis is also eaten. In Africa Lecanora esculenta is so abundant on sandy plains that it is gathered for food for man and beast. Many Arctic voyagers have prolonged and saved their lives by the use of species of Umbilicaria—rock-lichens (*Tripe de roche*). In Japan a species of the genus Endocarpon,, also common in Illinois, is used as food. Valuable dyes were formerly obtained from several lichens, such as Roccella tinctoria, Lecanora tartaraea, Parmelias, etc. The new

discoveries in chemistry did away with their use in civilized nations. Lichens were once valued highly as remedies for various diseases, and some species are still used, as Peltigera canina. Theloschistes parietinus, Cladonia aphthosa, and numerous other forms of various genera, all common to our own country and easy of investigation by students.

LICHENS OF THE TERRITORY INCLUDED IN THE SURVEY.

The species enumerated are represented in the "Exsiccati of North American Lichens," deposited in the collection of the Chicago Academy of Sciences by the author. The descriptions of species are made from studies of the specimens, comparisons, and study of other authors.

SERIES 1. GYMNOCARPI.

TRIBE 1. PARMELIACEI.

FAMILY 1. USNEEI.

Ramalina, (Ach.) De Not. Thallus fruticulose, or pendulous, subcompressed, pale-greenish; apothecia scattered, or marginal, scutellæform. Spores colorless, bilocular.

1. **R. calicaris,** (L.) Fr. Thallus tufted, rather rigid; longitudinally lacunose; apothecia flattish. Spores ellipsoid.
   On oaks near Riverside; at Lemont on stony bluff, and in Will County.

2. **R. calicaris,** Fr., var. **fraxinea,** Fr. Thallus wide and long-lobed; apothecia lateral.
   On oaks and old fences near Lemont.

3. **R. calicaris,** Fr., var. **fastigiata,** Fr. Lobes short, often straw-colored, crowded, branched; apothecia terminal, subfastigiate.
   Along lake shore and throughout our territory, on oaks.

Cetraria, (Ach.) Fr., Mull. Thallus ascendant with compressed, turgid, or channelled branches; or may be expanded and foliaceous-membranaceous; brown, yellowish, or glaucescent; apothecia marginal or submarginal, scutellæform, often dilate. Spores sub ellipsoid.

4. **C. ciliaris,** (Ach.) Thallus membranaceous, foliaceous, sinuate-laciniate; greenish or brownish; brownish beneath, fibrillose; lobes crowded, often narrowed and cleft, lacunose; apothecia marginal, ample; disk chestnut, margin crenulate. Spores subellipsoid. Ach. L. U., p. 508. Platisma, Nyl. 5, Syn. 308.
   On old rails in Lemont Township; on old birch at Glencoe.

5. **C. aleurites,** (Ach.) Th. Fr. Thallus membranaceous, foliaceous, divided or cleft, isidiod, plicate at centre; beneath pale, wrinkled, fibrillose; lobes sinuate-laciniate, with crenate tips; apothecia marginal, granulate on the margin, brown, medium size. Spores round.
   On old rails near Lemont and Joliet.

FAMILY 2. PARMELIEI.

Theloschistes, Norm. (Physcia, Nyl.) Thallus foliaceous or reduced, appressed or ascendant; membranaceous, orange or yellowish, apothecia scutellæform; disk yellow, orange or greenish-yellow. Spores ellipsoid, polar-bilocular or simple.

6. **T. chrysophthalmus,** (L.) Norm. Thallus tufted, more or less erect, spreading; the branches narrow, linear, smooth or puberulent; tips mostly fibrillose and ramulose; apothecia few; disk orange, which is often fibrillose. Spores ellipsoid. Parmelia chrysophthalma. Ach. M. L. 267.

In Hanover Township, Cook County, and Will County; at Lemont, on old rails in woods. Also on old oak trees near the lake shore, Lake View.

7. **T. parietinus,** (L.) Norm. Thallus, foliaceous, sub-orbicular, crenate, yellow and orange, lobes appressed, sub-imbricate, radiant, rounded; apothecia small to ample, orange, border entire or flexuous. Spores ellipsoid. Parmelia, Fr., L. E. 72; Xanthoria, Th. Fr. L. Scand., 145.

Along the lake shore, on oaks and poplars; also in Lemont and elsewhere.

8. **T. lychneus,** (Nyl.) Thallus reduced, substellate, or effuse, yellow; apothecia scattered; yellow-orange, entire or granulate. Spores ellipsoid.

On walnut and hickories, west part of Cook County and elsewhere. It has a numerous synonomy, and is often considered a variety of No. 7.

9. **T. concolar,** (Dickson) Tuckerm. Thallus foliaceous, orbicular, greenish-yellow; divisions narrow, much dissected; beneath pale, fibrillose; apothecia small, yellow or rufous. Spores numerous. Physcia candelaria, Nyl., etc.

On various trees along the lake shore at Glencoe. All the genus may be distinguished by the golden or yellow thallus. May be mistaken for Placodium.

Parmelia, (Ach.) De Not. Thallus imbricate—foliaceous, lobate or laciniate, appressed, membranaceous; more or less fibrillose, sometimes densely so; apothecia scutellæform, slightly pedicellate. Spores ellipsoid. *Vide* Schwendener.

10. **P. perlata,** (L.) Ach. Thallus greenish-glaucescent, or whitish; dilated; lobes rounded, often sorediate, undulate; black beneath, with brown margins; apothecia small to large, rufous, entire. Ach. L. U. 459, etc.

Found throughout our territory on oaks and other trees, and on boulders near Lemont.

11. **P. perforata,** (Jacq.) Ach. Thallus whitish, much dilated; coriaceous, membranaceous, glaucescent, smooth, sinuate lobed; beneath black or fuscous; fibrillose; apothecia very large, perforate, cyathiform; disk fuscuous or rufous. Spores ellipsoid. Ach. L. U. 459, etc.

On various trees in Cook and Will Counties. A common species.

12. **P. crinita,** Ach. Thallus dilated, membranaceous, surface covered with minute granules and branchlets; black beneath and fibrillose; lobes ciliate; apothecia ample, cyathiform; disk chestnut. Fr., L. E., 58.

On oaks in Hanover Township; on detached rock near Lemont; not common.

13. **P. cetrata,** Ach. Thallus greenish, dilated, rather thin, smooth; beneath black and hispid; the sinuate lobes sorediferous on the margins, narrowed, soon prolonged; apothecia medium size, chestnut. Ach. Syn. L., 198, etc.

On trees and stones near Lemont and westward.

14. **P. tiliacea,** (Hoffm) Fl. Thallus smooth, closely adnate, much narrowed, membranaceous, margins crenate; lobes rounded, sinuate-laciniate; apothecia medium size, few, margins crenulate. Fr. L. E. 59, etc.

On oaks at Riverside, Lemont and Hanover. There are varieties in the South.

15. **P. tiliacea,** Fl., var. **sulphurosa,** Tuck. Medullary layer sulphur-yellow; otherwise like the species. Tuckerm, Syn. 1, 57.

Found near Elgin on oak trees. Will probably be found elsewhere.

16. **P. borreri**, Turner. Thallus cinereous, glaucescent; lobes large or narrow, rugulose; beset with round soredia; membranaceous; pale brown beneath, fibrillose, dense; apothecia large, badio-rufous, margin entire. Spores rounded. Turner. Linn. Tr. 148. Ach. L. U. 461, etc.

Very common everywhere in our territory, especially on oaks.

17. **P. borreri**, Turn., var. **rudecta**, Tuckerm. Thallus isidioid. Ach. Syn. 197. Tuckerm. Syn. 58.

Occurs on oaks in the west part of Cook County, and at Lemont and Joliet.

18. **P. saxatilis**, (L.) Fr. Thallus glaucous-cinerascent, membranaceous, more or less lacunose, ramose; isidiophorous; beneath black and densely fibrillose; lobes sinuate-multifid, incised; apothecia large, disk fuscous, or spadiceous, margin subcrenulate. Spores ellipsoid. Fr. L. E. 61. Nyl. Syn. 388.

Found on trees in Cook County near Elgin and on recent sandstones and boulders at Lemont.

19. **P. saxatilis**, Fr., var. **sulcata**, Nyl. On bluff boulders and stones near Lemont, and in Will County. Very fine specimens may be gathered in LaSalle County.

The very numerous soredia, which are round or oblong, confluent and reticulate, mark the variety. Tuck. Syn. 58.

20. **P. physodes**, (L.) Ach. Thallus loosely attached, substellate, whitish, coriaceous, glaucous; beneath fuscous-black, no fibrils; lobes many cleft, complicate, often with white soredia; apothecia medium to large, badio-rufescent, margin nearly entire. Spores subellipsoid. Ach. S. L. 218. Tuckerm. Syn. 59, etc. Occurs on oaks in Cook and Du Page Counties, and elsewhere. There are several varieties in other States.

21. **P. caperata**, (L.) Ach. Thallus substramineous, dilated, coriaceous, undulate-plicate, often sorediate; beneath black, fibrillose; lobes sinuately-laciniate, rounded tips; apothecia large, chestnut, margin subcrenulate, often sorediate. Ach. S. L. 196, etc.

Very common on oaks everywhere. The fruit is seldom seen here, but the lichen is conspicuous for size and color.

22. **P. conspersa**, (Ehrh.) Ach., Thallus straw-colored, greenish, laciniate, much divided, appressed, often isidiophorous in the centre; beneath fuscous-black, sparingly nigro-fibrillose; lobes sinuate, often crenate, or pinnatifid, complicate; apothecia large, chestnut, margin subcrenulate. Spores ellipsoid, simple. Ach. L. U. 486. Muhl. Catal. 1818 Tuckerm. Syn. 64, etc.

In Lemont and Will County on stones; also found near Elgin on old wood. This species has a wide distribution in the United States.

23. **P. colopodes**, (Ach.) Nyl. Thallus coriaceous, glaucescent, beneath dark brown, spongy nap, with a few fibrils; lobes sinuate-cleft, flat; apothecia large, disk chestnut. Spores numerous. Tuck. Syn. 61; Nyl. Syn., etc.

On oaks near Lemont. There is a very narrow lobed form not as yet observed here.

Physcia, (D. C., Fr.) Th. Fr. Thallus foliaceous, variously divided, stellate, somewhat fibrillose; apothecia scutellæform. Spores ellipsoid, bilocular.

24. **P. speciosa**, (Wulf.) Nyl. Thallus greenish, glaucous, loosely stellate, appressed, beneath corticate, rhizinæ whitish; lobes sinuate, flat, pinnatifid, with powdery margins; apothecia medium size, sessile, margin crenulate; disk fuscous. Spores bilocular. Parmelia speciosa, Ach. L. U. 480; Fr. L. E. 80; Tuck. exs. n. 81; Calkins exs.

Occurs at Riverside on oaks; on hickories, near Elgin and other localities.

25. **P. stellaris**, (L.) Nyl. Thallus albo-glaucescent, stellate, appressed, orbicular; beneath pale, fibrillose, lobes linear, many-cleft, compaginate, or discrete; apothecia small, sessile; disk fuscous-black, often grey-pruinose, margin entire or crenulate. Parmelia, Fr. L. E. 82.

This, the most common species of the genus, occurs everywhere on oaks, hickories and other trees, as well as on rocks.

26. **P. stellaris**, (L.) Nyl., var. **aipolia**, Nyl. Thallus brown becoming blackish, beneath black, fibrils hispid; apothecia subcrenate, Nyl. Scand., 111. Parmelia, Ach. S. L. 215.

Found on boulders of the prairies and on stones at Lemont.

27. **P. tribacia,** (Ach.) Tuckerm. Thallus smallish, membranaceous, sub-stellate, glaucescent; beneath white, fibrillose; lobes short, appressed; margins erose, granulate; apothecia small, sessile, black or pruinose, margin sub-entire. Lecanora, Ach. S. L. 191. Tuck., etc.

On elms at Glencoe, and in other localities on hickory. A variety of P. stellaris, (d.) of Tuck. Syn., 75.

28. **P. obscura,** (Ehrh.) Nyl. Thallus stellate, orbicular, appressed, epruinose, glaucous, fuscescent, beneath black, fibrillose, lobes many-cleft, flatish; ciliate; apothecia rather small; disk nigro-fuscous, margin entire. Spores bilocular. Th. Fr., Scand. 142. Harmelia, Fr. L. E. 84.

On hickories and other trees in west part of Cook County; near Lemont and Joliet on trees and calcareous rocks. Quite variable everywhere, having several forms.

29. **P. adglutinata,** (L.) Nyl. Thallus often slightly olivaceous, also cinerascent and brown, adheres closely to substrate, small; lobes thin, flat, compaginate; apothecia small, disk nigro-fuscous, margin entire. Nyl. Syn. 438, etc.

On elms and hickories in Cook and Will Counties. This is a well marked species.

30. **P. granulifera,** (Ach.) Tuckerm. Thallus glaucescent and white, pruinose, be-sprinkled with powdery granules; beneath pale, corticate, fibrils black; lobes multifid, dentate-crenate; apothecia small, inflexed margin crenate. Parmelia, Ach. Syn. L. 212. Tuckerm. Obs. 390.

Found on hickories near Elgin and at Lemont. A variety of P. speciosa (e. of Tuck.), but quite marked.

FAMILY 3. PELTIGEREI.

Peltigera, (Willd., Hoffm.) Fee. Thallus membranaceous, lobate, frondose, foliaceous; beneath somewhat villous, marked with veins, occasionally cyphels; apothecia peltæform. Spores fusiform. Cortical layer, in some species consisting of gonidia, in others, of gonimia.

31. **P. rufescens,** (Neck.) Hoffm. Thallus large, coriaceous, rotund, lobate, lobes elevated and crisp, ash colored to reddish-brown; beneath reticulated with brown veins, fibrillose; apothecia on lobules, large; disk revolute, rufo fuscous. Spores acicular. Fr. L. E. 46. Tuck. exs. n. 104. Calkins. exs.

Occurs at Glencoe in ravines and on hillsides, on earth and old mossy logs. Found also at River Forest near the Desplaines River and throughout our territory.* Tuckerman says this species stands in embarrassing relations to P. canina.

FAMILY 4. PANNARIEI.

Heppia, Naeg, Thallus squamose-foliaceous, monophyllous, Gonimous layer of gonimia; apothecia round, immersed. Spores ovoid.

32. **H. despreauxii,** (Mont.) Tuckerm. Thallus small, round, smooth, or regulose, green; apothecia separate, or in rosettes, sunken in thallus, disk reddish or salmon-colored.

Found on calcareous earth near Lemont. This curious lichen being very small is not easily seen. It seems always to be associated with Endocarpon hepaticum in habitat, and has often been mistaken for a fungus.

Pannaria, Delis, Thallus squamulose, subfoliaceous or monophyllous, the hypothallus spongy or obsolete; apothecia scutellæform, with both thalline and proper margins, frequently biatorine. Gonimous layer of both gonidia and gonimia.

33. **P. nigra,** (Huds.) Nyl. Thallus squamulose, minute, lead colored, and mostly merged into a granuloid crust; apothecia small, biatorine, sessile; disk black, margin entire.

On calcarieous rocks near Lemont and in Will County.

FAMILY 5. COLLEMEI.

Collema, (Hoffm.) Fr. Thallus greenish, cortical layer obsolete; gonimia in chains; apothecia very small to middle size; scutellæform. Spores variously shaped.

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*Other species of this genius are likely to occur.

34. **C. pycnocarpum**, Nyl. Thallus small, pale, green, sub-orbicular, lobes radiate, narrowed, fenestrate, ribbed, the marginal lobules densely fruited; apothecia small; disk reddish, excluding margin. Spores ovoid ellipsoid, bilocular, decolorate. Nyl. Syn., 115.

Found on elms and shrubs in Will County; rare.

35. **C. microphyllum**, Ach. Thallus small, fuscous-green, or olivaceous, orbicular, diffract or effuse, microphylline; lobes often granulate, crenate at centre; apothecia abundant, small, urceolate, rufescent, flat; thalline margin entire, concolorous. Spores sub-muriform. Ach. Syn. L., 310.

On elm bark; Cook and Will Counties; rare.

36. **C. flaccidum**, Ach. Thallus dark-green, or olive-green; lobes large, expanded, bullate, entire, with concolorous granules, undulate plicate, paler beneath; apothecia small, sessile; disk rufescent, margin entire. Spores ovoid. Ach. Syn. L., 322; Tuck. Gen., 91.

Occurs near Elgin and Joliet on oaks and elms; rare. May be found on rocks also.

37. **C. tenax**, (Sw.) Ach. Thallus thin, lobes wide, appressed, also ascendant, lead-colored; apothecia often immersed; disk rufescent, the margin entire or rogose. Var. c. of **C. pulposum**, Tuck., exs. n., 148. Calkins, exs.

Found near Joliet on calcareous soil; rare.

38. **C. limosum**, Ach. Thallus thin, dark green, scattered, slightly crenate, pulpy when wet; apothecia rufous, immersed but becoming superficial, margin prominent, entire or somewhat crenulate. Spores in fours in the thekes. Nyl. Syn., 110.

Inhabits clay soil. Will County; rare.

39. **C. granosum**, (Wulf.) Schaerer. Thallus small, rigid, gelatinous when wet; lead-colored; lobes ample, rounded or elonggated and divided; apothecia of medium size, sessile; disk reddish, dark. C. dermatinum, Ach. L. U., 64.

On mossy rocks near Desplains River, Will County.

Leptogium, (Fr.) Nyl. Thallus foliaceous, or fruticulose, cortical layer distinct; gonimia in chains; apothecia sub-scutellæform, lecanorine or sub-biatorine. Spores of various forms.

40. **L. lacerum**, (Sw.) Nyl. Thallus plumbeo-fuscescent, lacero-laciniate, ample, wrinkled, the lobes dilated above and sinuate, thin, crisped and dentate; apothecia small, pale-red, sub-sessile, margin entire. Spores ovoid-ellipsoid. Ach. L. U. 657.

On elms in Hanover Township, near Elgin; also in Will County.

41. **L. chloromelum**, (Sw.) Nyl, Thallus small to large; orbiculate, rigid; plumbeo-virescent, lobate, plicate, rugose; apothecia medium size, lecanorine, plane, rufous, the thalline margin granulate. Spores ovoid. Nyl. Syn. 128. Tuck. Gen. 98.

On elms in Hanover Township, near Elgin; also in Will County. The varieties are found further south.

42. **L. myochroum**, (Ehrh. Schaerer) Tuckerm. Thallus ample, coriaceous, membranaceous, sub-monophyllous, also loosely attached, lead colored and blackish; beneath has a whitish nap; apothecia reddish, border plicate. Spores ellipsoid. Tuck. 99.

On the same substrate as the preceding species, Will County.

43. **L. pulchellum**, (Ach.) Nyl. Thallus small to large, rosulate, glaucous-green, lobes plicate, papulose, wrinkled above and beneath and pitted; apothecia medium size, lecanorine, sub-pedicellate, disk fusco-rufous, finally excluding the smooth or finally rugose thalline margin. Spores ovoid-ellipsoid, sub-muriform, decolorate. Collema, Ach. Syn. L. 321. Tuck. Syn. 161. Calkins, exs.

Found on calcareous rocks in Will County, and on elms in Cook County. Better developed further south in this State.

FAMILY 6. LECANOREI.

Placodium, (D C.) Naeg. & Hepp. Thallus crustaceous, lobed, suffruticulose, or uniform; apothecia sub-scutellæform, lecanorine or sub-biatorine; disk usually yellow or orange. Spores ellipsoid, polar-bilocular, colorless.

44. **P. cinnabarinum**, (Ach.) Anzi. Thallus rimose-areolate, more often of applanate scales, crenate, and crowded into an imbricate crust, orange; apothecia minute or small, adnate; disk orange, margin entire. Spores ellipsoid. Lecanora, Ach, L. U. 402. Parmelia, Fr. L. E. 165.

Very common on calcareous and arenaceous rocks in our territory.

45. **P. microphyllum,** Tuckerm. Thallus squamulose; from greenish-yellow to orange; scales adnate, crowded and concealed by granules; apothecia small, adnate, flat, orange; proper margin entire, the thalline one crenulate. Spores ellipsoid. Tuck. Syn. 174.

Found near Lemont, on old fence panels, and in Will County.

36. **P. aurantiacum,** (Light.) Naeg. & Hepp. Thallus uneven and chinky, warted, broken; yellow or variously colored, often bordered by a dark hypothallus; apothecia fair size, sessile, zeorine, flat; disk lemon, saffron or tawny colored; proper margin thin, the thalline one crenulate or may be obsolete. Parmelia, Fr. L. E. 165. Lecanora, Nyl. Scand. 142. Tuck. Syn. 174. Calkins, exs.

On elms and poplars at Glencoe; on hickories and other trees along the Desplaines river; on rocks at Lemont, and elsewhere. Thallus and apothecia lemon color, in our specimens; abundant.

47. **P. ferrugineum,** (Hudson) Hepp. Thallus chinky, verruculose, ash-colored, upon a black hypothallus; apothecia fair size, mostly biatorine, sessile, flattish; disk opaque, rust-colored, or fulvous, bordered by a crisp proper margin, often enclosed in a thalline one. Parmelia, Fr L. E. 170. Caloplaca, Th. Fr. Scand. 182. Tuck. Syn. 177.

On oaks along the Desplaines river and near Elgin on hickories. Not so common as the preceding species, but plentiful.

48. **P. vitellinum,** Ehrh. Thallus effuse, tartareous, squamaceous, of crenate granules, crowded into heap-like areoles, often dispersed, greenish-yellow; apothecia small, sessile, flat, yellow; thalline margin granulate-crenate. Spores numerous, simple and bilocular. Fr. L. E. 162. Nyl. Scand. 141. Tuck. Syn. 180.

Found on dead wood and rails in Lemont Township. Not common for lack of proper conditions.

Lecanora, (Ach.) Tuckerm. Thallus crustaceous; mostly uniform; apothecia scutellæform, or zeorine. Spores ellipsoid, or oblong.

49. **L. pallida,** (Schreb.) Schaerer. Thallus thin, membranaceous, smooth, cream-colored or darker; apothecia sessile, tumid; whitish-buff, white-pruinose, the entire margin disappearing. Spores ellipsoid. Parmelia, Schaer. Spicil. 396. Tuck. Syn., 185.

On oaks and hickories near Joliet. This species and its varieties are more abundant in some localities than in ours. Varies greatly as to the apothecia.

50. **L. subfusca,** (L.) Ach. Thallus whitish or cinerascent, smooth, rimulose, granulate, verrucose, soon diffract; apothecia plano-convex, disk fuscous, becoming black, often pruinose, the thalline margin entire, flexuous or crenate. Spores ellipsoid. Parmelia, Schaer. Spicil. 389, etc.

Very common in our territory on oaks and other trees and also on arenaceous rocks. There are several varieties. I have specimens from Europe, Japan and the West Indies. Many species, so called, have been made from this cosmopolite.

51. **L. subfusca,** (L.) Ach., var. **allophana,** Ach. Thallus granulate, verrucose; apothecia fuscous-black, margin flexuous and crenate. Lich. Uni. Nyl. 395.

On oaks in various localities; not uncommon.

52. **L. subfusca,** (L.) Ach., var. **argentata,** Ach. Apothecia smaller, margin entire. Spores smaller. Lich. Univ. Nyl. Syn. 393.

Occasionally found on shrubs and trees in our territory.

53. **L. subfusca,** (L.) Ach., var. **distans,** Ach.

Common on the same substrates as the preceding forms; apothecia flat and pale, margin crenulate. Spores smaller than in number 52. L. distans, Ach. L. U. 397.

54. **L. hageni,** Ach. Thallus cinerascent, verruculose or wanting; apothecia small or minute, crowded, plane or tumid; pale to fusco-rufous or sometimes pruinose; margin white, commonly crenate or entire; may be excluded. Th. Fr. Scand. 250. L. umbrina, (Massalongo) Nyl.

On rails near Lemont and on calcareous rocks. Some conditions are known as L. umbrina, (Mass.) Nyl. The observer cannot but see close relations in L. hageni to L. subfusca and the next following species.

55. **L. hageni**, Ach., var. **sambuci**, (Pers.) Nyl., L. Sambuci, Nyl. Th. Fr.

Found rarely on elms, poplars and shrubs in Will County.

56. **L. varia**, (Ehrh.) Nyl. Thallus verruculose, greenish or yellowish; apothecia small, the disk yellow to flesh-color or rufescent, thin; margin entire or crenulate, often excluded. Spores oblong-ellipsoid. Nyl. Scand. 163.

On oaks near Elgin, Lemont and elsewhere. There are numerous varieties.

57 **L. varia**, (Ehrh.) Nyl., var. **symmicta**, Ach. Thallus thin, whitish; apothecia yellowish, disk swollen, excluding margin; biatoroid. Fr. L. E. Nyl. Tuck. Syn.

On various trees.

58. **L. calcarea**, Sommerf. Thallus white, contiguous; apothecia innate, emerging; disk grey-pruinose. Spores ovoid-ellipsoid. Nyl. Scand. 154.

On calcareous rocks at Joliet.

59. **L. calcarea**, Sommerf., var. **contorta**, Fr. Areoles discrete, pale lead-color. L. calcarea, f. Hoffmani, Nyl.

On calcareous rocks at Joliet. A very curious form.

60. **L. cervina**, (Pers.) Nyl. Thallus tartareous, areolate, squamulose; scales sub-peltate, from yellowish to chestnut; apothecia medium size, impressed, becoming superficial; disk reddish-brown, thalline margin obsolete. Nyl. Scand. 174. Tuck. 202.

On detached sandstones in Cook and Will Counties.

61. **L. privigna**, (Ach.) Nyl. Thallus wanting; apothecia varying from small to large; sessile, appressed; scattered or aggregated; disk dark red; margin elevated, rugged, contorted. Spores numerous, minute Lecidea, Ach. M. L. 49. Sarcogyne, Koerber, Syst. 266. Biatorella, Th. Fr. Scand. 407.

Found on calcareous pebbles near Elgin, on rocks near Joliet.

62. **L. privigna**, (Ach.) Nyl., var. **pruinosa**, (Auctt.) Apothecia small, appressed, sunken; disk gray-pruinose. Sarcogyne, Koerber. Lecanora, Nyl.

On sandstone boulders near Lemont. This, and the two preceding forms, are so nearly related that one is puzzled to distinguish them without a familiar acquaintance with suites of specimens from different localities. The most perfect representations of the variety are from the Trenton rocks of LaSalle County, Illinois, and from Tennessee.

The variety clavus, Koerber, should be found in our limits also.

63. **L. perproxima**,* Nyl. Spec. nova. Resembles L. erysibe, Ach., nevertheless the spores are larger, .014-18 by .007 mm., and the hymenial gelatine with iodine is a beautiful blue, becoming deep blue. In appearance it resembles L. cæsio-cinerea, Nyl.

On calcareous rocks at Joliet and elsewhere.

64. **L. erysibe**, Ach. Thallus cinerous, thin, diffract; apothecia fusco-rufous, plane or convex.
On calcareous rocks in Will County; abundant.

Rinodina, Mass. Stizenb. Tuckerm. Thallus crustaceous, apothecia scutellæform, often zeorine, then lecideine. Spores ellipsoid, bilocular, brown.

65. **R. sophodes**, (Ach.) Nyl. Thallus gray or cinereo-fuscescent; apothecia small, appressed; disk flat, fuscous-black; margin entire. Nyl. Scand., 148. Th. Fr. Scand. 199. Tuck. Syn. 207.

On boulders near Lemont. I have not met with it elsewhere so far north.

66. **R. bischoffi**, (Hepp.) Koerber. Thallus ash-colored or fuscescent; thin, farinose; apothecia small, sessile, flat or convex; margin fuscescent or cinerascent. Spores broad, fruit finally lecideoid. Th. Fr. Scand. 204. Tuck. Syn. 209.

On calcareous rocks at Joliet and Lemont. A little known species. Occurs more abundantly further south and west.

*L. perproxima, Nyl. Spec. Nova. Proxima L. erysibe, Ach. Sporis nonnihil majoribus, long. 0.014-18, crass. 0.007 millim., et gelatina hymenialis. Iodo bene cœrulescente, cœrulescentia persistente. Facies fere Lecanora cæsio-cinerea, Nyl.

Pertusaria, D C. Thallus crustaceous, continuous, smooth or verrucose; apothecia globular, difform, closed; enclosed in thalline verrucæ, opening by pores (ostioles); explanate, lecanoroid. Spores generally large, ellipsoid.

67. **P. velata,** (Turn.) Nyl. Thallus white, glaucescent, rugose, chinky, rimose, radiate near the circumference; apothecia small, adnate, pale yellowish, white powdery; the thalline margin disappearing in the fruit. Muhl. Br. L. 274. Tuck. Syn. 212.

On rocks and trees.

68. **P. multipuncta,** (Turner.) Nyl. Thallus ash colored, rugose, verrucose, zonate at the circumference; apothecia small, in verrucæ—2–4; lecanoroid, finally elevated; disk becoming black, soon excluding the thalline margin and often forming powdery heaps. P. faginea, Tuck. Syn. N. E. 64.

On oaks and hickories; not rare.

69. P. **communis,** D C. Thallus glaucescent, smooth, chinky or rugose-verrucose, may become zonate at the circumference; apothecia small, adnate, depressed, sub-globose, difform, closed, the numerous ostioles sunken and black. Spores generally in twos, sometimes solitary. Porina pertusa, (L.) Ach. Syn. L. 109, etc.

Common on oaks everywhere in our territory.

70. **P. leioplaca,** (Ach.) Schaer. Thallus whitish or more commonly pale-yellowish; apothecia medium size, globular and difform, often crowded together; depressed ostioles indistinct, often blackening. Nyl. Scand. 181. Tuck. Syn. 215.

On oaks near Elgin and elsewhere.

71. **P. pustulata,** (Ach.) Nyl. Thallus greenish or whitish; chinky, or verruculose; apothecia very small, hemispherical and difform, globular or confluent; ostioles black. Spores in twos. Porina, Ach. L. U. 309. Tuck. Syn. 215.

On trees; general in distribution here and elsewhere.

Conotrema, Tuckerm. Thallus crustaceous, uniform; apothecia urceolate, truncate-conoid. Spores cylindraceous, pluri-locular.

72. **C. urceolatum,** (Ach.) Tuckerm. Thallus smooth, becoming chinky and rugged, whitish; apothecia small, urceolate, from black to pruinose; prominent, elevated. Lecidea, Ach. L. U. 671. Gyrostomum, Fr. Tuck. Gen. L. 129. Conotrema, Tuck. Syn. 217.

This, the only species of the genus and has a wide distribution. Found on maples and poplars in Cook and Will Counties; also further west and south in Illinois. The genus Gyalecta should occur with this in our territory, affording at least the two species, G. lutea and G. trivialis, Willey. They are very small and may have escaped discovery here, though found in southern Illinois.

Urceolaria, (Ach.) Flotow. Thallus crustaceous, uniform; apothecia urceolate. Spores ovoid-ellipsoid, muriform, pluri-locular; fuscescent.

73. **U. scruposa,** (L.) Nyl. Thallus tartareous, rugose-plicate; glaucous, ash-colored or white; apothecia immersed, but emerging, urceolate, large, black; disk somewhat cinereous; margin denticulate, hidden by the thalline one, if present. Nyl. Scand. 176. Tuck. Syn. 222. Muhl. Cat. 1818.

Found on calcareous earth in Will County and on dead cedars along the banks of the Illinois; rare.

TRIBE II. LECIDEACEI.

FAMILY 7. CLADONIEI.

Cladonia, Hoffman. Thallus squamulose, rarely granulose or deficient; apothecia variously colored, but never black; soon inflated and cephaloid; podetia fistulous, funnel or tubulose in shape, often shrub-like. Spores small. Tulasne, Mem. sur. les Lich. Tuck. Gen. Lich. and Syn.

74. **C. mitrula,** Tuckerm. Thallus of small squamules, minute, green; podetia short, granulate, glaucescent; apothecia confluent, flesh-colored or brown. Tuck. in Fl. Cestrica. 444. Nyl. Syn. 203.

On earth and old logs in Cook and Will Counties. Generally distributed west and south.

75. C. **pyxidata,** (L.) Fr. Thallus squamulose; podetia cup-shaped, warty, turbinate, ash-colored; the cups cyathiform; often proliferous; apothecia brown. Nyl. Syn. 192. Tuck. Syn. 241.

Formerly abundant on earth along the lake shore in woods. Common elsewhere in our territory, on earth and rocks.

76. C. **pyxidata,** (L.) Fr., var. **Pocillum,** Ach. Has foliaceous thallus and reduced podetia.

Occurs rarely in our limits.

77. C. **fimbriata,** (L.) Fr. Thallus squamulose, but reduced; the podetia elongated, often white-powdery; cups with erect margins; apothecia brown. Fr. L. E. 222.

Found on rotten logs at Glencoe, and elsewhere on logs and earth.

78. C. **fimbriata,** (L.) Fr, var. **tubaeformis,** Fr. Podetia slender, elongated, tawny-brown, often with squamules; cups smaller, toothed or entire; proliferous, fimbriate; apothecia confluent. Tuck. Syn. 241.

Found throughout our territory. Synonomy numerous.

79. C. **gracilis,** (L.) Nyl. Thallus squamulose, but often wanting, ash-green; podetia slender to robust, corticate, polished, proliferous; apothecia fuscous. Nyl. Syn 196, C. ecmocyna, Ach.

On earth in Will County.

80. C. **gracilis,** (L.) Nyl., var. **verticillata,** Fr. Cups proliferous from the centre, dilated.

On earth in Will county.

81. C. **squamosa,** Hoffman. Thallus much divided; podetia much branched; apothecia cymose, fuscous. Fr. L. E. 231. Nyl. Tuck. Syn. 246.

On earth and rotten logs in Will County and the western part of Cook.

82. **C. delicata,** (Ehrh.) Fr. Thallus reduced, more often of crowded white granules; podetia short, slender; apothecia heaped, fuscous. Nyl. Syn. 210. Tuck. Syn. 6. C. parasitica, Schaer.

Found near Elgin on old stumps, near Lemont, and elsewhere. Very closely related to C. squamosa, Hoffm. *Vide*. Fr. L. E.

83. **C. furcata,** (Hudson) Fr. Thallus squamulose but small; podetia fruticulose, elongated, corticate; brownish-green, fertile summits corymbose, pervious; apothecia brown. Fr. L. E. 229. Tuck. Syn. 247.

On calcareous soil near Joliet and elsewhere.

84. **C. rangiferina,** (L.) Hoffm., var. **sylvatica,** L. Horizontal thallus wanting; the podetia two to four inches high; cinerascent, erect, branched and imbricate, terminal ones divaricated, corymbose. A more delicate form than the species. Fr. Tuck., etc.

Occurs on dead wood and sandstones in the Desplaines Valley, but is more common further west. The species is found from the arctic circle to the tropics in one form or another. Known as the "Reindeer moss."

85. **C. cristatella,** Tuck. Thallus squamulose, minute, cut and crenate; podetia fair size, often elongated, cylindrical, corticate; smooth or wrinkled, summits fastigiate; apothecia scarlet, or as var. b. Tuck. ochrocarpia, C. flœrkiana Tuck Syn. N. E. 55, etc.

Found occasionally in our territory on old decaying logs and stumps.

86. **C. macilenta,** (Ehrh.) Hoffm. Thallus squamulose, minute, crenate, lobate; podetia cylindrical, slender, granulose-pulverulent above; apothecia terminal, confluent, scarlet. Fr. L. E. 240. Tuck. Syn. N. E. 55.

On earth and logs in woods near Joliet; rare. This and No. 85 may be easily identified by the scarlet fruit.

Myriangium, Mont. and Berk. Thallus cellulose, orbiculate, plicate-striate at the circumference, nodulose; apothecia lecanoroid. Spores oblong-ovoid.

87. **M. duriaei**, (M. & B.) Tuckerm. Thallus crustaceous, adnate, becoming free, fuscous; apothecia elevated, blackish, disk with depressed, entire margin. Tuck. Gen. L. 140. M. curtisii, M. & B.

Collected several years ago on Corylus near River Forest; not observed elsewhere. Common south. Its position among the lichens is considered doubtful.

FAMILY 8. LECIDEEI.

Biatora, Fr. Thallus various or deficient; apothecia diverse in color, becoming soft and swollen when wet. Spores ellipsoid and simple, or assuming different forms, colorless, numerous.

88. **B. coarctata**, (Ach.) Th. Fr. Thallus cinereous, of minute squamules, rimose-areolate; apothecia small, fuscous or blackish, connivent or open, sometimes flat. Spores ovoid-ellipsoid. Lecidea, Nyl. Scand. 196. Tuck. Syn. Pt. 2. 15. Parmelia, Fr. L. E. 104.

On calcareous and arenaceous rocks in Will County; also found on detached sandstones in Cook County. A widely distributed and variable species.

89. **B. varians**, Ach. Thallus of minute granules compacted into a yellowish or greenish crust, which is granulate or broken; apothecia very small, yellowish, rufous or blackish; disk flat, margin thin. B. exigua, (Chaub.) Fr. L. E. 278.

On oaks and hickories near Elgin and Lemont.

90. **B. rubella**, (Ehrh.) Rabenh. Thallus yellowish or grayish-green, effuse, confluent; apothecia luteo-rufescent, or reddish-brown; scattered or congregate, becoming tumid and margin excluded, the latter often whitish. Spores pluri-locular. Lecidea, Schaer. Spicil. 168. Bacidia, Th. Fr. Scand. 344. Biatora, Tuck. Syn. Pt. 2. 44.

This widely diffused species occurs in our county on hickories and oaks. It is variable, and a number of varieties, fourteen or more, have been created species. Each has an extensive synonomy.

91. **B. fusco-rubella**, Hoffm. Thallus granulate, rugose, chinky, ash-colored; apothecia medium size, sessile, flat; disk often turgid, rust-colored, chestnut, or even black. Bacidia, Th. Fr. Scand. 346. Lecidea spadicea, Ach. Syn. L. 34. Tuck. Syn. Pt. 2. 43. (Var. b.)

In same localities as the preceding species.

92. **B. suffusa**, Fr. Thallus the same as in No. 91. Apothecia ample, reddish brown, suffused partially or wholly with white; disk rufescent, becoming darker, turgescent, excluding the margin, suffused with white. Tuck. Gen. Lich. 166. (Var. c.) Tuck. Syn. Pt. 2. 43.

On hickories in Hanover, Cook County, and near Lemont and Joliet.

93. **B. inundata**, Fr. Thallus scurfy, greenish, rimose-areolate; apothecia minute, sessile or adnate, flat or convex; tumid-brownish, black, often excluding the margin; hypothecium pale. Spores slender. Secoliga, Stizenb. Bacidia, Koerb. Biatora. Tuck. Syn. Pt. 2. 45.

In all our territory on detached rocks or stones along streams; the thallus is best shown on sandstones.

94. **B. cyphalea**, Tuckerm. Thallus thin granulose, cinerascent; apothecia small, dark reddish or rust-colored. Tuck. Syn. Pt. 2. 51, and Gen. L. 168.

Rare on elms near the Fox River; may be found elsewhere.

Lecidea, (Ach.) Fr. Tuckerm. Thallus various, crustaceous, squamulose or evanescent; apothecia patellæform, horny. Spores colorless. Fr. L. E. Tuck. Syn.

95. **L. enteroleuca**, Fr. Thallus granulose and cinerascent, often wanting; apothecia small to large, adnate, convex, often excluding margin, black. Spores ovoid-ellipsoid. Fr. L. E. 331. Tuck. Syn. N. E. 67. Nyl. Scand. 217.

This species has many forms and has been described under various names. Some of them occur on rocks and mosses, others on trees. It is found on maples in Will County. It is the only species of the genus within our limits so far as known. There are six described varieties in the United States.

Buellia, (De Not.) Tuckerm. Thallus mostly uniform; apothecia patellæform. Spores ellipsoid, brown or decolorate.

96. **B. parasema,** (Ach.) Th. Fr. Thallus cinerascent or darker, rugose, granulate, glaucescent; apothecia sessile, black; disk flat, often turgid; margin thin. Lecidea, Fr. Tuck. Syn. N. E. 67. L. disciformis, Nyl.

On oaks near Elgin and elsewhere on dead wood. Occurs everywhere in North America; a variable species.

97. **B. schaereri,** De Not. Thallus granulose, often wanting, cinerascent; apothecia very small, black, flat; disk turgescent and margin wanting. Lecidea nigritula, Nyl. Scand. 238.

Found on an old stump near Lemont, also on old rails; not common. Is also found in Grundy and LaSalle Counties.

TRIBE 3. GRAPHIDACEI.

FAMILY 9. OPEGRAPHEI.

Opegrapha, (Humb.) Ach. Nyl. Thallus hypophlæous, or, if exposed, thin; apothecia normally lirellæform.

98. **O. atra,** (Pers.) Nyl. Thallus thin or wanting; apothecia sessile, black, simple, flexuose; disk open, canaliculate, proper margin thick, elevated, wavy.

Throughout our territory on oaks, hickories, cherries, etc.

99. **O. varia,** (Pers.) Fr. Thallus white, pulverulent; apothecia prominent, elongate, oblong, elliptical, attenuate at the ends, brownish-black, dilated in the centre; margin inflexed.

On various trees in Cook and Will Counties.

Graphis, (Ach.) Nyl. This genus has been fully discussed by Nylander, who followed the thought of Acharius, and by Tuckerman, in his Genera Lichenum, 203; Syn Pt 2. 119. Thallus crustaceous, uniform; apothecia mostly lirellæform, and branching, but in some species rounded, difform; the proper exciple colored or black. Differentiated from Opegrapha by the spores.

100. **G. scripta,** (L.) Ach. Thallus thin, whitish, even or rugose, sub-tartareous; apothecia immersed or half immersed, slender, width uniform, simple or branched, obtuse at ends; proper margin narrow, wavy; thalloidal margin tumid. Spores colorless.

Common everywhere on oaks, hickories and other trees; apothecia variously branched. There are a number of varieties which may occur here.

101. **G. dendritica,** Ach. Thallus white or yellowish, thin, pulverulent; apothecia brownish-black, immersed, broad, flexuose-branched, forked; disk broad, often cæsio-pruinose; margin thin.

On oaks and various trees within our limits. These two species seem to be the only ones of this genus in northern Illinois. One other can be added for the southern portion of the State. When compared with the exuberance of forms in Florida, derived, however, from semi-tropical or tropical sources, this is a small number. The limitation of species is well illustrated by tracing this genus from south to north.

FAMILY 10. GLYPHIDEI.

Arthonia, (Ach.) Nyl. This genus, containing a great number of species mostly tropical, is one of the most perplexing. Dr. Nylander, more than twenty years ago, described about one hundred species. Henry Willey in his "Synopsis," published in 1890, admits three hundred and forty-eight species, and mentions a few more that he had not seen. About eighty of these are from the United States, four or five of which were discovered by the author. The genus should have been spelled Ardonia, according to its derivation from the Greek, but long usage has sanctioned the present spelling. The genera Chiodecton and Glyphis, which immediately precede

Arthonia, are not found in our territory, but inhabit Florida. We have several species of Arthonia, two so abundant as to be easily identified.

102. **A. lecideella,** Nyl. Thallus green, uneven, effuse; apothecia abundant, small, round, plain, pruinose. Spores oblong-ovoid. Nyl. En. 337. Tuck. Gen. 221. Willey, Syn. 16.

On hickories and Cratægus throughout our territory.

103. **A. spectabilis,** Fl. Thallus thin, white; apothecia black, difform, angulate, plain or convex, often bordered by the thallus. A. dispersa, Duf. A. polymorpha, of Muhl. Catal. 1818. Willey, Syn. 51.

On maples at Glencoe, Riverside and elsewhere. It is also found on other trees. Synonyms numerous.

104. **A. diffusa,** Nyl. Thallus white, effuse or wanting; apothecia round or difform, plane or convex, pruinose. A. willeyi. Tuck. in litt. Willey, Syn. 36.

On hickories and maples in Will County; not common.

105. **A. pyrrhuliza,** Nyl. Thallus white, thin; apothecia reddish, slender, much divided, ramose. Willey, Syn. 15.

On oaks in Will County; rare. Was once considered the A. medusæa of Tuckerman. May occur on Cratægus, in which case it is more likely to be noticed.

106. **A radiata,** (Pers.) Th. Fr. Thallus whitish, darkening, or obsolete; apothecia dark-brown, stellate, difform or ramulose, erumpent. Opegrapha, Pers. (1794). Arthonia, Th. Fr. Arctic. 240. A. astroidea, Ach. Syn. 6. Willey, Syn. 44.

Has many synonyms, and until lately was known as A. astroidea, Ach. Found on oaks near Elgin and elsewhere. The variety swartziana, Nyl. should also occur within our limits.

107. **A. taediosa,** Nyl. Thallus indeterminate; apothecia erumpent, linear, heaped, few branched and sometimes round.

On maples in the Desplaines valley; also found on oaks. The name is very applicable, its habit, as to form, may be called sportive.

NOTE.--Tribe 4, including the genera Siphula, Sphærophorus, Acroscyphus, Acolium, Calicium and Coniocybe, have not been found in our territory. The two latter genera are possibilities.

SERIES II. ANGIOCARPI.

TRIBE V. VERRUCARIACEI.

FAMILY 11. ENDOCARPEI.

Endocarpon, (Hedw.) Fr. Thallus foliaceous, or crustaceous, peltate; apothecia imbedded, minute. Spores colorless. For exposition consult Tuck. Gen. Lich. 246.

108. **E. miniatum,** (L.) Schaer. Thallus cinereous, large, peltate, lobate-crenate, umbilically affixed; underside smooth or rugose, fulvous; apothecia numerous and minute, immersed, brownish.

On calcareous rocks near Lemont and elsewhere. The species has a wide distribution; is found in Europe and Japan, being used in the latter country, as I am informed by Prof. Minakata, as an article of diet. The thallus is often one inch or more in diameter. Abundant in Illinois.

109. **E. miniatum,** (L.) Schaer., var. **complicatum,** Schaer. A polyphyllous form.

Found on limestone rocks at Lemont and elsewhere.

110. **E. miniatum,** (L.) Schaer., var. **muhlenbergii,** Ach.
Occurs with the first named and is scarcely distinct.

111. **E. hepaticum,** Ach. Thallus fuscous, squamose, small, round or angular; apothecia numerous, blackish. Ach. L. U. 298. (1810). Nyl., etc.

On calcareous earth at Lemont and in Will County.

112. **E. pusillum,** Tuckerm. Thallus very small, greenish, thin; apothecia minute, imbedded.

Very abundant throughout our territory on various rocks and stones. The genus Endocarpon was founded upon this species. V. pallida, Nyl. Ach. L. U.

113. **E. rufescens,** Ach. Thallus rufescent, squamose, lobes rotundate, incised, complicate. Ach. L. U. 304. (1810).

On earth in Will County. Not easily distinguished from E. hepaticum, but is darker and thinner, and the spores are smaller.

FAMILY 12. VERRUCARIEI.

SUB-FAMILY PYRENULEI.

In the following genera we approach the limits marking the close relations of the lower lichens with the fungi. The absence or slight indications of a thallus have caused Lichenologists to doubt whether certain species of Verrucaria and Pyrenula, should be classed under these names, or as Sphærias. The effort has been made to eliminate the myco lichens, all corticolous, from the true ones. Fries expressed this idea,* and that a distinction be made between the saxicoline and corticoline groups, which, seeming a natural arrangement, I have followed. Tuckerman conceived the sub family as naturally divided into two great classes: "the one," to quote his own language, "(confined to inorganic substrates) of true lichens, with a well marked thallus, and the other (confined to organic substrates) of plants, the thallus of which is more or less obsolete, and the affinity close to Pyrenomycetous Fungi." But even with a fair array of evidence in support of this arrangement, Nylander dissents from this view.†

Sagedia, (Mass.) K'br. Tuckerman. Thallus crustaceous; apothecia innate-superficial. Koerber. Syst. 362. Nyl. Pyrenoc. 36, classed under Verrucaria. Tuck. Gen. Lich. 263.

114. **S. oxyspora,** Tuckerm. Thallus thin, effuse; apothecia black, ellipsoid, conoid; perithecium black. V. albissima, Nyl. Scand.

Occurs on Betula papyracea along the lake shore near Glencoe. The few native birch will soon disappear and with them this species.

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*Syst. Orbis Viget. 264.

†Nyl. Pyrenoc.

Verrucaria, (Pers.) Tuckerm. Thallus crustaceous, sub-tartareous, mostly uniform; apothecia globular, black, immersed or prominent; perithecium black. The synonomy of this genus is numerous. Tuck. Gen. Lich. 263. Verrucaria is restricted here to the rock and earth lichens, species taken from Pyrenula and other genera, which, as Tuckerman remarks, shows a full and harmonious spore-character. In Europe a large number of forms have been included under Verrucaria, but Fries and Nylander have made a great reduction.

115. **V. prospersella,*** Nyl. Spec. nova. Thallus uninterruptedly white or scattered, becoming chinky with age reaction; apothecia pyrenoid, wholly black, small (breadth, .15 mm.), somewhat globose, rather prominent. Spores 8. colorless, oviform, 1 septate, .018-22 by .008-.011 mm. The paraphyses few or scarcely any. Hymenia gelatinous-reaction. Occurs on siliceous rocks near Chicago. (Calkins). This species seems to approach V. inconspicuam, Lahm, from which it differs by its larger spores. Likewise near to V. saxicola, Mass. The calcicolous species, V. ruderella, Nyl. also occurs in the same locality. Nyl. Chall. p. 217.

First found at Riverside. Described and published by Dr Nylander in his "Obs." Lichens Japoniæ, Paris, 1890 Abundant so far as known.

116. **V. pyrenophora,** (Ach.) Nyl. Thallus tartareous, chinky, ash-colored or continuous and rugulose; apothecia prominent, black, large conoidal, sessile; perithecium dimidiate. Spores 8, colorless. Ach. L. U. 285. (1810).

On rocks at Riverside, Lemont and throught our territory.

117. **V. nigrescens,** Pers. Thallus nearly black, crustaceous, uneven, crumbling, and often raised around the apothecia; apothecia black; perithecium dimidiate. Spores 8, colorless.

On limestone along streams in various localities.

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*V. prospersella, Nyl, Spec. nova, Thallus albidus continus, vel passim obsolete rimulosus; apothecia pyrenio integre nigro, minuta (latit. 0,15 millim.), subglobulose prominula: sporae 8 nae incolores oviformes 1-septatæ, long. 0,018-22, crass. 0,008-011 millim: paraphyses graciles parcæ vel vix ullæ. Gel. hym. I. Super saxum siliceum haud procul a Chicago (Calkins). Accedere videtur ad V. inconspicuam, Lahm. a qua mox differt sporis majoribus. C. fr. etiam V. saxicola, Mass.--Calcicola ibidem (idem) V. ruderella, Nyl. Chall. p. 217.

118, **V. fuscella,** Fr. Thallus crustaceous, dark brown, areolate-diffract., black-limitate, smooth: apothecia minute, immersed in the areolæ. Spores 8, colorless. Ach. L. U. 289.

Found on detached calcareous rocks near Joliet; not common as far as observed. A well defined and interesting species.

119. **V. muralis,** Ach. Thallus whitish, tartareous, mealy or wanting; apothecia black, semi-immersed, hemispherical; perithecium dimidiate.

Found on limestone near Joliet and in Cook County, and sometimes on old mortar.

120. **V. viridula,** Ach. Thallus greenish olive, areolate-diffract, areolæ polygonal, smooth or rugose, effuse; apothecia black, numerous, semi immersed. Spores 8, colorless.

On detached calcareous rocks, north bluff at Lemont

Pyrenula, (Ach., N. & H.) Tuckerm. Thallus hypophlœoid, subcortical, rarely ektophlœoid, superficial; apothecia denudate, perithecium black, ellipsoid-oblong, etc.

121. **P. gemmata,** (Ach.) Naeg. Thallus whitish, thin; apothecia black, medium to large, prominent, convex; perithecium black, dimidiate. Spores colorless. Ach. Meth. Lich. 120. (1803). Acrocordia, K'br.

On oaks and hickories at River Forest and in all our territory This species is closely related to Sphæria mastoidea, Fr.

122. **P. punctiformis,** (Ach.) Naeg. Thallus thin, effuse, brown; apothecia black, shining, minute, sessile-innate, conoid; perithecium dimidate. V. epidermidis, Nyl. Offers a near approach to Fungi according to Fries, Wallroth, Tuckerman.

On Quercus alba near Elgin and elsewhere.

123. **P. thelaena,** (Ach.) Tuckerm. Verrucaria, Ach.
On birch trees at Glencoe; on maples and hickories near Riverside.

124. **P. nitida**, Ach. Thallus pale yellowish or olive, waxy, smooth; apothecia black, in size medium to large, though sometimes small, invested by the thallus, globose; perithecium black. Spores fuscous. Sphæria, Weigel, Obs. 45. (1772). Verrucaria, Ach. L. U 279. Nyl., etc.

On oaks and maples throughout our territory, perhaps not abundant, yet it may be in some places. The very pale thallus will identify its location more easily. American specimens vary greatly in size.

125. **P. glabrata**, Ach. Thallus whitish, thin; apothecia variable in size, black, hemispherical, conoid; perithecium black. Spores fuscous. Ach. Syn. 791. Nyl. Pyren. 47.

On oaks near Elgin and Joliet; apparently not common. Some Florida specimens are of extraordinary size, making their proper position questionable.

Bibliography of North American Lichenology.

The following is believed to be a nearly complete list of the publications on the North American Lichens issued previous to April 15th, 1896:

Acharius, E. Lichenographia Universalis. 1810.

———. Synopsis Lichenum. 1814.

Numerous species are described in both works.

Arthur, J. C., Bailey, L. H. and Holway, E. W. D. Plants collected between Lake Superior and the International Boundary, 1896. Geol. and Nat. Hist. Surv. Minn. Bull. No. 3:31-32. IO1887.

Enumerates thirty-seven species.

Bailey, L. H. *See* **Arthur, J. C.**

Bell, Robert. A List of Plants Collected on the South and East Shores of Lake Superior and North Shore of Lake Huron in 1860. Ann. Bot. Soc. Canada. **1**:78. 1861.

Mentions seven species.

Bogue, E. E. Catalogue of the Lichens of Ohio. Jour. Cinc. Soc. Nat. Hist. Ap1893.

Enumerates 166 species.

Bolander, H. N. A Catalogue of the Plants Growing in the Vicinity of San Francisco, California. 1870:41.

Mentions the Lichens.

Calkins, William Wirt. Catalogue of Lichens Collected in Florida in 1885. Jour. Mycology. **2**:112. 1886.

———. Notes on New Florida Lichens. Bull. Torr. Bot. Club. D1889.

———. Notes on Rare East Tennessee Lichens. Am. Naturalist. N1890.

———. Note on a New Edible Lichen. Bot. Gaz. D1892.

———. Remarks on American Lichenology. Science. 26Ag1892. —9O1892.—10F1893.

———. The Lichen-Flora of Chicago and Vicinity. Geol. and Nat. Hist. Surv. The Chicago Acad. Sci. Bull. No. 1:1-52. Ap1896.

General consideration of the Lichens; describes one hundred and twenty-five species and varieties; notes on the habitat of each species.

———. *See* **Eckfeldt, John W.**

Cragin, F. W. Note on Kansas Lichens. Bull. Washburn Col. Lab. Nat. Hist. **1**:64. Ja1885.

Enumerates two species with notes regarding their habitat. Lists fifteen species and varieties collected by Elihu Hall in Kansas and recorded in Tuckerman's "North American Lichens."

———. Enumerates ten aditional species of Kansas Lichens, collected by Elihu Hall and recorded in Tuckerman's "North American Lichens." Bull. Washburn Col. Lab. Nat. Hist. **1**:176. J11886.

Cummings, Clara S. List of Lichens from Alaska. Bull. Torr. Bot. Club. 10Ag1892.

Enumerates twenty-nine species.

Curtis, M. A. List of Lichens. Geol. and Nat. Hist. Surv. N. Carolina. 3:77-83. 1867.

Enumerates two hundred and seventeen species.

Day, David F. The Plants of Buffalo and Vicinity—Cryptogamæ. Bull. Buffalo Soc. Nat. Sci. **4**:167-173.

Enumerates forty-five genera and two huadred and four species and varieties.

Drummond, A. T. Additions to the Canadian Lichen-Flora. Can. Nat. Mr1874.

———. List of Canadian Lichens. Can. Geol. and Nat. O1865.

Drummond, N. T. On the Economical Uses of Sticta Pulmonaria. Ann. Bot. Soc. Canada. **1**:81.

Durand, Elias. Lichens in Plantæ Kaneanæ Groelandicæ. Jour. Phila. Acad. Nat. Sci. 1856.

Eckfeldt, John W. An Enumeration of Some Rare N. A. Lichens. Bull. Torr. Bot. Club. **19**:249. 1892.

———. Lichens from California and Mexico. Contr. Nat. Herb. **1**:291. 31O1893.

Enumerates forty-two species with short notes.

———. Chemical and Medicinal Properties of Some Lichens. Med. Bull. Philadelphia. 1894.

———. An Enumeration of the Lichens of Newfoundland and Labrador. Bull. Torr. Bot. Club. **22**:25Je1895.

———. Catalogue of Plants found in New Jersey. (By N. L. Britton.) Geol. Surv. N. J. **2**[1]:357-384. 1889.

The list of Lichens is a revision by Dr. Eckfeldt, of the Prelimary Catalogue printed from the manuscript of C. F. Austin, and based on specimens named by Prof. Tuckerman. Enumerates fifty-four genera and three hundred and twenty-nine species and varieties,

Eckfeldt, John W. and Calkins, William Wirt. Catalogue of the Lichen-Flora of Florida. Jour. Mycology. **3**:121-133. 1887.

An enumeration of three hundred and thirty species, many of which are new.

Fink, Bruce. The Lichens of Iowa. Bull. Lab. Nat. Hist. St. Univ. of Iowa. **3**[3]:70-88. 26Ag1895.

Enumerates one hundred and ninety-six species with notes.

Frost, W. D. Determination of some Minnesota Lichens. Bull. Geol. and Nat. Hist. Surv. Minn. 9:81-85. 21Mr1894.

Gerard, W. R. Note on Omphalaria pulvinata, Nyl. Bull. Torr. Bot. Club. D1875.

Gronovius, D. J. F. Flora Virginica. (Pub. at Leyden). 1739.

This is the first mention of North American Lichens.

Hall, F. W. List of Lichens within Twenty Miles of Yale College. Am. Nat. **11**:170. Mr1877.

Hall, Elihu. *See* **Wolf, J.**

Halsey, A. Synopsis of Lichens near New York. Ann. Lyc. Nat. Hist. **1**:1-19. *f*4. 1823.

A valuable work enumerating one hundred and seventy-six species, some of which are new and described by Schweinitz.

Hitchcock, Edward. Catalogue of Animals and Plants of Massachusetts. Geol. Rep. Mass. 1835.

Enumerates one hundred and sixteen species.

———. Catalogue of Plants Growing near Amherst, Mass. 1829.

Enumerates the Lichens.

Hooker, J. D. Flora Boreali-Americana. (Pub. in London). 1840.

Gives a general view of American Lichens.

Hasse, H. E. List of the Lichens of Los Angeles County, California. Erythea. Mr1895.

Enumerates one hundred species.

———. Supplementary List of the Lichens of Los Angeles County, California. In Litt.

Kellerman, W. A. and Werner, W. C. Cat. of Ohio Plants. Geol. Surv. Ohio. **7**:56-106. 1895.

Enumerates thirty-six genera and one hundred and fifty-eight species and varieties with their hosts.

Knowlton, F. H. Algo-Lichen Hypothesis. Am. Mo. Mic. Jour. **7**:101.

Lapham, L. A. The Lichens of Wisconsin. Trans. Wis. State Agri. Soc. **1860**:8.

Leighton, W. A. Lichens Collected by Sir J. Richardson in Arctic America. *pp*17. *pl*26. *f*8. 1867.

Leinhart, Rev. E. Greeley's Narrative of the Franklin Bay Expedition. **2**:397.

Seven species are mentioned

———. Additions to the Flora of Washington. Proc. Biol. Soc. **3.**

Lindsay, W. L. What to Observe in Canadian Lichens. Ann. Bot. Soc. Canada. **1**:49.

———. The Lichen-Flora of Greenland. 1870.

Macoun, John. Lichens of British Columbia. Rep. Geol. Surv. Canada. **1877**:227.

———. Annotated Catalogue of Lichens of the Dominion of Canada, Newfoundland and Alaska.

In Litt. to be published during 1896-7.

Michener, E. Lichens in Darlington's Flora Cestrica, 3rd, Ed. 1853.

Valuable. Enumerates and describes one hundred and five species.

Millspaugh, C. F. and Nuttall, L. W. Flora of West Virginia. Field Columbian Museum, Chicago. Bull. 2. 1895.

Enumerates the Lichens with descriptions of three new species.

Muhlenberg, Index Floræ Lancastriensis. Trans. Am. Phil. Soc. Philadelphia. **3.** 1793.

Enumerates thirty species.

———. Catalogus Plantarum Americæ Septentrionalis. 1818.

Enumerates one hundred and eighty-four species; many new.

———. Eaton's Manual, 6th Edition. 1833.

The species enumerated in the preceding catalogue are described.

Muller, J. Lichenes Eckfeldtiana, etc. Bull. du L' Herbier Boissier. **2**:89. F1894.

Describe forty species from North and South America, chiefly from Mexico. One genus and several species and varieties are new.

McClatchie, A. J. Flora of Pasadena. Hist. of Pasadena, Cal. By H. A. Reid. 1895.

Enumerates forty-one species.

Nuttall, L. W. *See* **Millspaugh, C. F.**

Nuttall, Catalogue of Plants of the Pacific Coast. Phila. Acad. Sci. **7.**

Mentions Borrera columbiana.

Nylander, William. Lichenes Insularum Guineensium. Paris. 1889.

Describes, in an appendix, seventeen species mostly from North America, twelve of which are new Florida discoveries of the author of this Bulletin.

———. Lichenes Japoniæ. 1890.

Describes thirty-six species from North America, many of which are new, collected by the author of this Bulletin in Tennessee and Florida.

———. Sertum Lichenææ Tropical e Labuanet Singapore. 1891.

Describes twenty-eight species many being new forms, collected by the author of this Bulletin in Tennessee, Florida and Illinois.

Olney, Catalogue of Rhode Island Plants. Proc. Providence Franklin Soc. **1.** 1846.

Enumerates twenty-four species.

Peck, Charles H. Reports of the State Botanist of New York. Ann. Rep'ts State Mus. Nat. Hist.

In the reports of several years species are enumerated with notes regarding habitat.

Rothrock, J. T. Lichens Collected in Alaska by Dr. T. H. Bean in 1880. Proc. U. S. Nat. Mus. **7**:1-10. O1894.

Enumerates one hundred and ten species with copious notes.

Russell, John L. Notices of Lichens. Jour. Essex Co. Nat. Hist. Soc. **1.**

Speaks of eight New England species.

———. Notices of Lichens. Proc. Essex Inst. **1** and **2.**

Describes the new genus and species, Hydrothyria venosa.

———. Notices of Lichens. Proc. Boston Soc. Nat. Hist. 1840.—Am. Jour. Sci. 1840.—Hovey's Mag. Bot. 1840.—Hovey's Mag. Bot. 1850-2.

Stitzenberger, E. List of Lichens Collected by R. Reubeux in Western North America. Proc. Cal. Acad. Sci. II. **5**:535. 1895.

Sturgis, William C. On the Carpologic Structure and Development of the Collemaceæ and Allied Groups. Contr. Crypt. Lab. Harvard Univ. **25**:15-53. *pl*8. 9Ap1890.

Swartz, Lichen Americani. 1811.

Describes twenty-five species. This was the only number of the Journal issued.

Torrey, John. A Catalogue of Plants near New York. 1819. (Albany).

———. Usnea fasciata. Am. Jour. Sci. **6.**

———. Botanical Report. Expl. and Surv. for R. R. Route from Miss. River to Pacific Ocean. **7**3:22. 1856.

Enumerates four species.

Tuckerman, Edward. An Enumeration of Some Lichens of North America. Proc. Boston Soc. Nat. Hist. **2.** Further communication in **3** and **5.**

———. Observations on Some Interesting Plants of New England. Am. Jour. Sci. 1843.

Mentions two Lichens.

———. An Enumeration of North American Lichens. 1845. (Cambridge).

Two hundred and thirty-eight are mentioned; remarks on the systems of Oken, Fries and others; discusses the structure and general history of Lichens, following the views of Fries.

———. Synopsis of the Lichens of New England, the other Northern States and British America, 1848. (Cambridge).

Two hundred and ninety-five species are described.

———. Lea's Catalogue of the Plants of Cincinnati. 1849.

Fifty-three species are classified by Tuckerman.

———. Agassiz's Lake Superior. 1850.

Seventy-three species are classified by Tuckerman,

———. Botanical Report. Expl. and Surv. for R. R. Route from Miss. River to Pacific Ocean. **6**3:94. 1857.

Enumerates ten species and varieties.

———. Supplements to the Enumeration of North American Lichens. Am. Jour. Sci. 1858-9.

Sixty-six species are described.

———. Observations on North American and Other Lichens. Proc. Am. Acad. Sci. and Art. 1860-4.

———. Wilke's Exploring Expedition. 1861.

Contains descriptions of one hundred and four species.

———. Lichens of California, Oregon, etc. 1866. (Amherst).

Enumerates one hundred and eighty-four species.

———. Can Lichens be Identified by Chemical Tests? Am. Nat. **2**:104. Ap1868.

———. United States Exploration of the 40th Parallel. Rep. 1872:412.

———. Genera Lichenum. 1872. (Amherst).

An arrangement of North American Lichens. A valuable work of two hundred and eighty-one pages.

———. Note on Ramalina reticulata. Bull. Torr. Bot. Club. **3**:2. Ja1872.

———. Two Oregon Lichens. Bull. Torr. Bot. Club. **5**:20. Ap1874.

———. Catalogue of Plants Growing Within Thirty Miles of Amherst College. 1875.

———. Regensburg Flora. 1875.

Merely a note.

———. Observationes Lichenologicæ. Proc. Am. Acad. 1876. (Boston).

———. Report upon the Botanical Collections made in Portions of Nevada, Utah, California, Colorado, New Mexico and Arizona. U. S. Geog. Surv. W. 100d Meridian. **6**:350-351. 1878.

Enumerates sixteen genera and twenty-eight species and varieties.

———. Synopsis of the North American Lichens. Pt. 1. *pp*261. 1882. Part 2 was edited and published by Henry Willey in 1888.

Underwood. Lucien M. List of Cryptogams at Present Known to Inhabit the State of Indiana. Proc. Indiana Acad. Sci. **1893**:30-67. Ag1894.

Enumerates thirty species.

Watt, David A. P. A Provisional Catalogue of Canadian Cryptogams. Can. Nat. **2.** O1865.

Enumerates one hundred and fifty-six species.

Williams Thomas A. Flora of Nebraska. Nebraska Agri. Rep. 1889.

Enumerates two hundred and thirty-one species.

———. The Fruiting of Parmelia Molliuscula, Ach. Rept. Mo. Bot. Gard. **3**:169-170. *pl*1 28My1892.

———. Lichens of the Black Hills and Their Distribution. Bull. Torr. Bot. Soc. **20**:349. S1893.

———. Notes on Mexican Lichens. Am. Nat. **29**:480. My1895.

Webber, H. J. Appendix to the Catalogue of the Flora of Nebraska. Trans. Acad. Sci. St. Louis. **6**:12-13. 12Mr1892.

Enumerates twenty-three species, with notes.

Werner, W. C. *See* **Kellerman, W. A.**

Willey, Henry. Note on Biatora lucida. Am. Nat. O18 7.

———. American Lichenography. 1867.

———. The Spores of Lichens. Am. Nat. **4**:720. F1871.

———. Lichens Under the Microscope. Am. Nat. Je1871.

———. On Lichens Collected by Dr. Coulter. Rept. Geol. Surv. of the Territories. **6**:790. 1872.

———. A List of North American Lichens. 1873. (New Bedford).

———. Statistics and Distribution of North American Lichens. Bull. Buffalo Nat. Hist. Soc. O1873.

———. List of Illinois Lichens. Bot. Gaz. F1877.—Mr1878.

———. First Contribution to the Knowledge of Kansas Lichens. Bull. Washburn Col. Lab. Nat. Hist. **1**:16-17. S1884.

Enumerates sixteen species, with notes.

———. Lichens Not Previously Reported from Kansas. Bull. Washburn Col. Lab. Nat. Hist. **1**:176. Jl1886.

Five species are listed, with notes regarding habitat.

———. An Introduction to the Study of Lichens with a Supplement. 1887. (New Bedford). *pp*58. *pl*10.

———. Notes on Dermatiscum Catawbense, (Willey) Nyl. Bull. Torr. Bot. Club. **14**:134. Jl1887.

———. Notes on Some Lichens. Bull. Torr Bot. Club. **14**:222. O1887.

———. Review of Prof. H. Lojka's Lichenotheca Universalis. Bull. Torr. Bot. Club. **14**:247. N1887.

———. Notes on Trypethelium Kunzei, Fee. Bull. Torr. Bot. Club. **15** Je1888.

———. Lichens of Colorado. Syn. Flora Col. U. S. Geol. and Geog. Surv. Territories Misc. Pub. 4:161-163.

Enumerates fifty-four species and varieties, with notes,

———. A Synopsis of the Genus Arthonia. *pp*62. 1890. (New Bedford).

Describes three hundred and forty-eight species.

Wolf, John and Hall, Elihu. A List of the Mosses, Liverworts, and Lichens of Illinois. Bull. Ill. St. Lab. Nat. Hist. 2:27-34. Je1878.

Enumerates forty genera and two hundred and sixteen species and varieties.

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Vol. II, No. III. An Historical Sketch of the Chicago Academy of Sciences.

II. By the Geological and Natural History Survey:

Bulletin No. I. The Lichen-Flora of Chicago and Vicinity. By William Wirt Calkins. Price, 25.

In Preparation:

a. The Drift of the Chicago Area. By Frank Leverett, U. S. Geol. Surv.

b. Boring Records of Chicago and Vicinity. A reference bulletin.

c. Palæntology. By M. Fischer and W. C. Egan.

d. Minerals. By C. M. Higginson.

e. Lepidoptera. By W. E. Longley.

f. Mollusca. By Prof. Frank C. Baker.

g. Aves. By Frank M. Woodruff.

h. Reptilia and Batrachia.

i. Algæ. By Prof. C. B. Atwell.

j. Pteridophyta and Bryophyta. By Prof. E. J. Hill.

k. Flora of Cook County and Vicinity, (Phænogamia and Vascular Cryptogamia). By Prof. W. K. Higley and C. S. Raddin.

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THE

Chicago Academy of Sciences

THE

Pleistocene Features and Deposits

OF THE

Chicago Area.

BY

FRANK LEVERETT.

U. S. Geological Survey.

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CHICAGO:
DAVID OLIPHANT, PRINTER, 178 MONROE STREET.

LETTER OF TRANSMITTAL.

CHICAGO, ILLINOIS, April 1st, 1897.

DEAR SIR :

By direction of the Board of Managers of the Geological and Natural History Survey of The Chicago Academy of Sciences, I herewith submit to you for publication as Bulletin No. II of the Survey, the report on The Pleistocene Features and Deposits of the Chicago Area, prepared by Frank Leverett, of the United States Geological Survey, to be issued under the rules of the Academy governing such matters.

Respectfully,

WILLIAM K. HIGLEY,
Chairman.

THOMAS C. CHAMBERLIN,
Pres't of The Academy of Sciences.

DEDICATION.

This Bulletin is dedicated to Mr. George H. Laflin, who, interested in the advancement of science and in the work of our institutions of learning, has by his generosity made its publication possible.

The Board of Managers of the Geological and Natural History Survey of The Chicago Academy of Sciences:

WILLIAM K. HIGLEY, Chairman,
CHARLES S. RADDIN, Secretary.
THOMAS C. CHAMBERLIN.
GAYTON A. DOUGLASS.
THOMAS T. JOHNSTON.

THE GEOLOGICAL SURVEY.

The Board of Management of the Geological and Natural History Survey take pleasure in presenting the second of its proposed publications, a list of which may be found on the fourth cover page.

The history and aims of the survey are outlined in the first bulletin, The Lichen Flora, prepared by Mr. W. W. Calkins, and published through the generosity of Mr. Albert Dickinson. It is only necessary, therefore, to repeat here the extent of the territory covered by the survey. This area comprises Cook and Du Page Counties, and the nine north townships of Will County, in Illinois, and a portion of Lake County, Indiana, giving a surface of about forty-eight or fifty miles square, or a land surface of nearly 1800 square miles.

The present bulletin on the Pleistocene Features and Deposits of the Chicago Area, has been prepared by Mr. Frank Leverett, of the U. S. Geological Survey. The Board desires to express its appreciation of the time and labor that must have been taken from the stress of other duties in the preparation of this very creditable work as well as of the assistance given to Mr. Leverett by individuals and institutions, recognition of which has been made in the body of the text.

The Board wishes further to make acknowledgement of the courtesy extended by the Sanitary District of Chicago, which, through the kindness of Mr. T. T. Johnston, Assistant Engineer, prepared the maps and profiles from Mr. Leverett's manuscript copy.

All into whose hands this bulletin may come, will join with the members of the Board in appreciation of the generosity of Mr. George Laflin, whose prompt response to the request for funds to publish the bulletin is but another instance of the liberality which has marked his attitude towards the Chicago Academy of Sciences.

THE BOARD.

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Pleistocene Features and Deposits of the Chicago Area.

By FRANK LEVERETT.

INTRODUCTORY STATEMENT.

The Chicago area here discussed embraces not only the site of the city, but adjacent territory west and south, nearly to the Fox and Kankakee Rivers, and north nearly to the line of Illinois and Wisconsin. It is made to include the first great moraine which sweeps around the head of Lake Michigan, as well as several weak morainic lines lying nearer the lake. It includes also the ancient beaches of Northeastern Illinois and a portion of the outlet of the body of water which formed them. It is a country exceptionally full of varied and interesting features.

Some of the features, especially those pertaining to the old lake and its outlet, are discussed by Dr. Edmund Andrews, in an early volume of the Transactions of the Chicago Academy (1). The same features and some of the leading features of the glacial deposits were briefly discussed by Dr. H. M. Bannister, in his official reports to the State Geologist (2). A description of the principal moraine traversing this district, based upon studies by Prof. T. C. Chamberlin and Prof. L. C. Wooster, is given by Professor Chamberlin in an early report of the United States Geological Survey (3)

The paper which follows aims to discuss these features in the light of a somewhat detailed study of Pleistocene deposits, which I have had the privilege of making in this and adjacent districts. Carried on as this study has been, under the direction of Prof. T.

---

(1) The North American Lakes considered as Chronometers of Post glacial Time. By Dr. Edmund Andrews, Transactions of The Chicago Academy of Sciences. Vol. II, 1870, pp. 1-23.

(2) Geology of Cook County. By H. M. Bannister. Vol. III, 1868, pp. 239-244.
Geology of DeKalb, Kane and DuPage Counties. By H. M. Bannister. Vol. IV, 1870, pp. 111-113.
Geology of McHenry and Lake Counties. By Dr. H. M. Bannister. Ibid, pp. 126-131.

(3) Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch. By Thos. C. Chamberlin, Third Annual Report, U. S. Geol. Survey, 1881-82, pp. 322-325.

C. Chamberlin, I have had the benefit of counsel and guidance, which has been of great service and which it is a pleasure to acknowledge.

The studies in Illinois, upon which the present paper is based, were entered upon in 1886, near the beginning of my study of Pleistocene deposits, and the greater part of the work in the Chicago Area was done in that and the following season. The study in Northern Illinois was carried into greater detail than in most of the territory subsequently covered, chiefly because of the complexity of the features. Nearly every township was traversed at intervals so close as to give opportunity to see practically all of the surface, to examine the best natural exposures, as well as railway cuttings and other artificial exposures, and to collect records of nearly all the important borings. Portions of the district here discussed have been recently re-examined. This has in a measure made good the loss consequent upon the lapse of time, and has brought the interpretation into harmony with the present state of knowledge of Pleistocene events or stages.

OUTLINE OF TIME RELATIONS OR GLACIAL SUCCESSION.

The complexity of the glacial events is such that it will be advantageous to outline as clearly as possible at the outset the recognized glacial succession and thus learn the position of the drift of the Chicago Area in the series of drift sheets displayed in the Mississippi Basin and adjacent territory. The outline given below aims to present simply the recognized subdivisions. These may prove to differ widely in rank or importance. The main divisions here outlined seem to be much longer than the secondary divisions and they may be of very unequal length. They appear to have the rank of an epoch, or main division of a period, except the divisions of Lake history, which, perhaps, should be substages. The outline aims to cover the events between the deposition of the oldest recognized drift sheet and the final recession of the ice sheet into the region north of the Great Lakes. That region may furnish several additional substages and possibly one or more stages. The outline differs from that published by Prof. T. C. Chamberlin, in a recent number of the Journal of Geology (1), only in being a fuller presentation of substages in the Wisconsin drift series, and in including the lake history of this region.

OUTLINE OF THE DRIFT SHEETS AND INTERVALS.

1. Oldest recognized drift sheet—the Albertan of Dawson.
2. First, or Aftonian, interval of recession or deglaciation.
3. Kansan drift sheet of the Iowa geologists.
4. Second interval of recession or deglaciation.
5. Illinoian drift sheet.
6. Third, or preloessial, interval of recession or deglaciation.
7. Iowan drift sheet and main loess deposit.
8. Fourth, or postloessial, interval of recession or deglaciation.
9. Early Wisconsin drift sheets.
    - Substage 1. Shelbyville morainic system.
    - Substage 2. Champaign morainic system.
    - Substage 3. Bloomington morainic system.
    - Substage 4. Marseilles morainic system.
10. Fifth interval of recession, shown by shifting of ice lobes.

(1) Journal of Geology, Chicago University. Vol. IV, No. 7 October-November, 896, pp. 872-876.

11. Late Wisconsin drift sheets.
    Substage 1. Great bowlder belts and accompanying moraines.
    Substage 2. Valparaiso morainic system.
    Substage 3. Lake-border morainic system.
12. Lake Chicago submergence.
13. Emergence of plain, covered by Lake Chicago.
14. Partial resubmergence of plain, covered by Lake Chicago.
15. The present stage of Lake Michigan.

It appears from the above outline that the late Wisconsin series covers the entire Chicago Area. A brief discussion of the several drift sheets which preceded the Late Wisconsin will be of advantage, however, both for comparison and for the interpretation of the deposits of earlier drift found beneath the late Wisconsin within the Chicago Area.

Explanation of Map of North America.—The position of the four main centers of glaciation is indicated, viz.: The Cordilleran, confined chiefly to the region west of the Rocky Mountains; the Keewatin, extending over the area between the Rocky Mountains and Hudson Bay and reaching Central Missouri at its farthest point south; the Labrador, extending over the peninsula of Labrador, and the Great Lakes, with its extreme southwest terminus in Southern Illinois, and the eastern borders of Missouri and Iowa. (The eastern New England, New Brunswick, Nova Scotia and Newfoundland glaciation may be from small independent centers, but this can scarcely be considered as demonstrated.) The fourth center of glaciation is the Greenland, which is still largely ice covered. The Driftless Area of Southwestern Wisconsin and border districts stands between the fields covered by the Keewatin and Labrador ice sheets. South from this driftless area is a narrow belt covered first by the Keewatin and later by the Labrador ice sheet, as indicated in the text.

The principal glacial lakes are perhaps sufficiently outlined to be deciphered. Lake Agassiz is shown clearly. Lake Iroquois occupies the Ontario basin and border districts. The Warren and Algonquin Lakes are more difficult to decipher. Lake Warren is now restricted by several geologists to a body of water that discharged across Southern Michigan from the Erie-Huron basin. At that time Lake Chicago was occupying the south end of the Lake Michigan basin. A small predecessor of Lake Warren, called Lake Maumee, had southwestward outlet to the Wabash. A lake discharging southwestward from the Lake Superior basin was probably a contemporary of Lake Warren. At the Lake Warren stage the ice sheet was apparently covering the region about the straits of Mackinac, much of Georgian Bay, and the eastern end of Lake Ontario. Lake Iroquois, in the Ontario basin, is of later date than Lake Warren, and is thought to have been held in on the northeast by the ice sheet, as shown by studies of

Plate

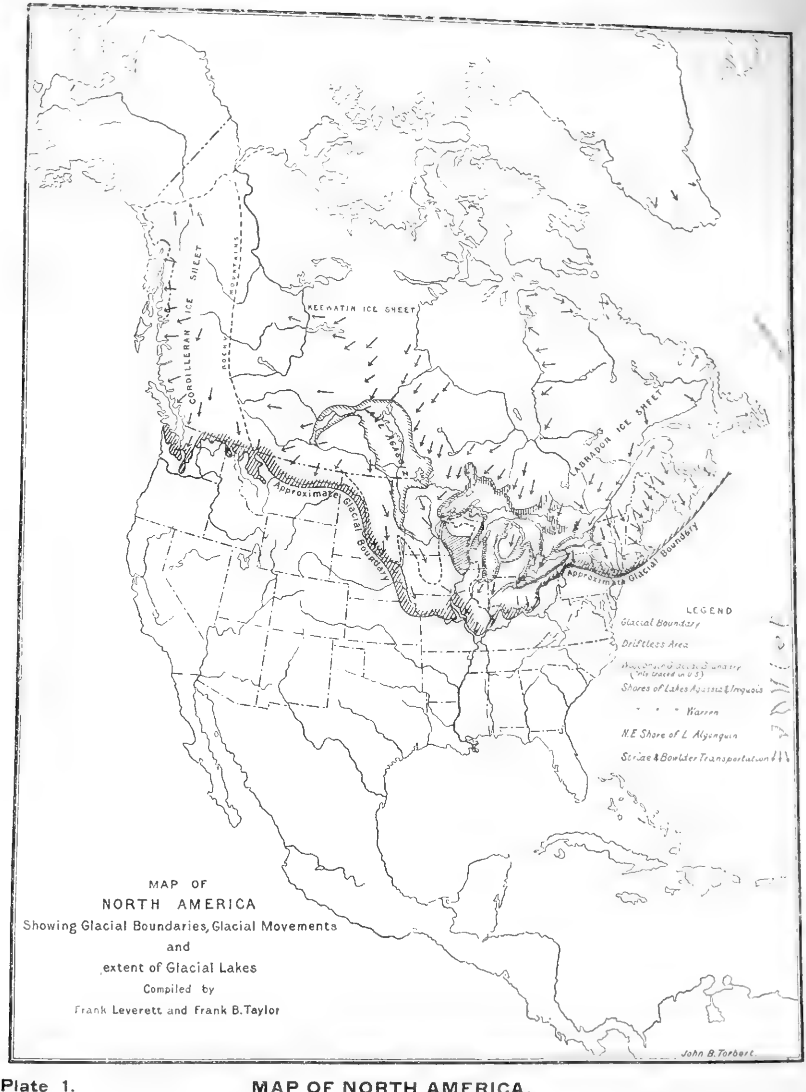


Plate 1. **MAP OF NORTH AMERICA.** [Inland Educator, August, 1896.]

Gilbert not yet published in full. Lake Algonquin represents a stage where an eastward outlet, from Georgian Bay by Trent River, to Lake Iroquois, was open, the outlet to the St. Clair being for a time above lake level. At that time the emergence of the south end of the Lake Michigan basin, discussed in the text, may have occurred. For the use of this map plate we are indedted to the Inland Educator Company of Terre Haute, Indiana.

ALBERTAN, OR OLDEST RECOGNIZED DRIFT SHEET.

Dr. George M. Dawson has recently called attention to a very aged drift sheet found by him in the province of Alberta, east of the Rocky Mountains, in Southern Canada (1). Its relation to drift sheets in the United States is not definitely worked out. It is overlain by a sheet that is probably either the sub-Aftonian (formerly Kansan) of Professor Chamberlin, or the somewhat later sheet to which the Iowa geologists have applied the name Kansan. Should the lower sheet prove to be the one that overlies the Albertan drift it will be necessary to place that drift in a still earlier stage than the sub-Aftonian of Professor Chamberlin, for it is described to be of markedly greater age than the drift sheet which overlies it.

AFTONIAN INTERVAL OF RECESSION.

The interval of recession or deglaciation, following the deposition of the lower till sheet of Southern Iowa, and named by Professor Chamberlin the Aftonian, from the type locality near Afton, Iowa, is characterized by soil and weathering of such a marked character that it no doubt will be recognized widely as the detailed study progresses. In the present stage of investigation it scarcely can be separated from soils of other horizons, except in the district which lies outside the Illinoian and the Iowan drift sheets. This district has not as yet received much study, hence the extent to which the soil remains intact is not known.

In Southeastern Iowa and Western Illinois several instances of the occurrence of a black soil between beds of till, and thought to be the Aftonian, have come to my notice. There is an element of uncertainty from the fact that it is near the border of the drift sheet, where minor oscillations of the ice margin are liable to have occurred, which may have caused the burial of soils whose extent is limited. It is not yet made certain that they mark a prolonged interval, such as Professor Chamberlin finds to be exhibited in the type locality near Afton.

(1) Bulletin Geological Society of America. Vol. 7, pp. 31-66. Issued Nov. 1895

KANSAN DRIFT SHEET OF THE IOWA GEOLOGISTS.

This is a sheet which has much importance in the drift series, for it constitutes a large part of the drift of Southern Iowa and Missouri and probably remains in extensive sheets beneath the later drift in districts to the north. It apparently extends into Western Illinois a short distance, beneath the Illinoian drift sheet. It is a sheet that has as yet received but little attention, the chief study given it being in Southeastern and Southern Iowa.

SECOND INTERVAL OF RECESSION OR DEGLACIATION.

This interval is known not by a recession and readvance of the same ice sheet, nor a sheet with the same gathering ground, but by the recession of one ice sheet and the advance of another ice sheet into the region thus abandoned. It has been studied only in Southeastern Iowa, where the Illinois lobe has encroached upon the territory which had been occupied by a more western lobe.

Evidences of the lapse of a long period between the withdrawal of one ice sheet and the invasion of the other are clear and decisive. The drift of the earlier sheet is a very calcareous till, yet its surface had been leached to a depth of several feet before the Illinois lobe encroached upon it.

Accompanying the leaching was the formation of a black or humus stained soil, numerous exposures of which are to be seen in Southeastern Iowa under the drift of the Illinois lobe.

There was also much erosion of the surface by stream action. Prior to the discovery of the extension of the Illinois lobe into Southeastern Iowa it had been noted by Professor Chamberlin, as well as by the writer, that Southern Iowa presents a more eroded appearance than Illinois and the southeastern counties of Iowa. In the former district remnants of the original drift plain are confined to narrow strips between water courses, while in the latter district such remnants are far more extensive, comprising much more than half the surface. It is planned to make a careful measurement of the relative amounts of erosion in the two districts, for erosion studies made with proper analytical method promise to furnish the most satisfactory means available for measuring such time intervals.

ILLINOIAN DRIFT SHEET.

Under this name is included the sheet of drift which covers Western Illinois and extends a few miles into Southeastern Iowa.

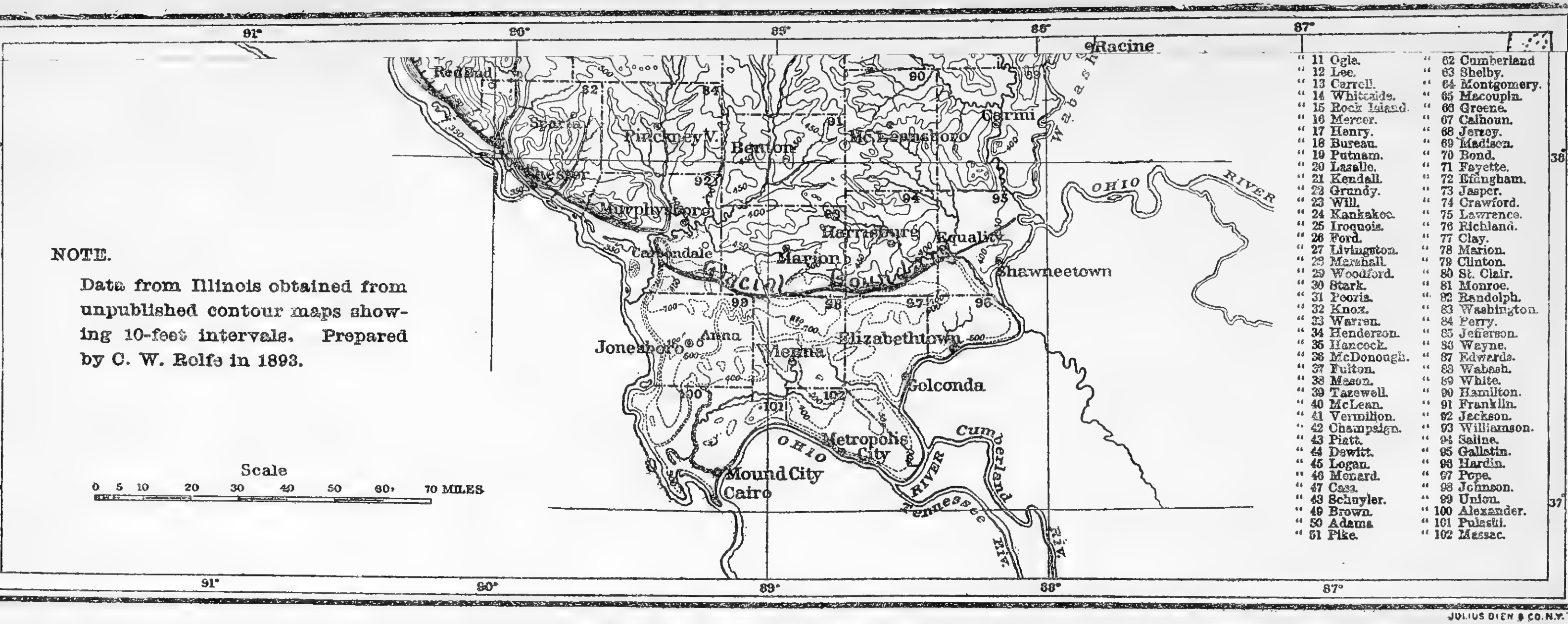


Plate 2.

MAP OF THE ILLINOIS LOBE

Modified from Plate CVIII and CIX. Seventeenth Annual Report, U. S. Geological Survey, Part 2, 1896.

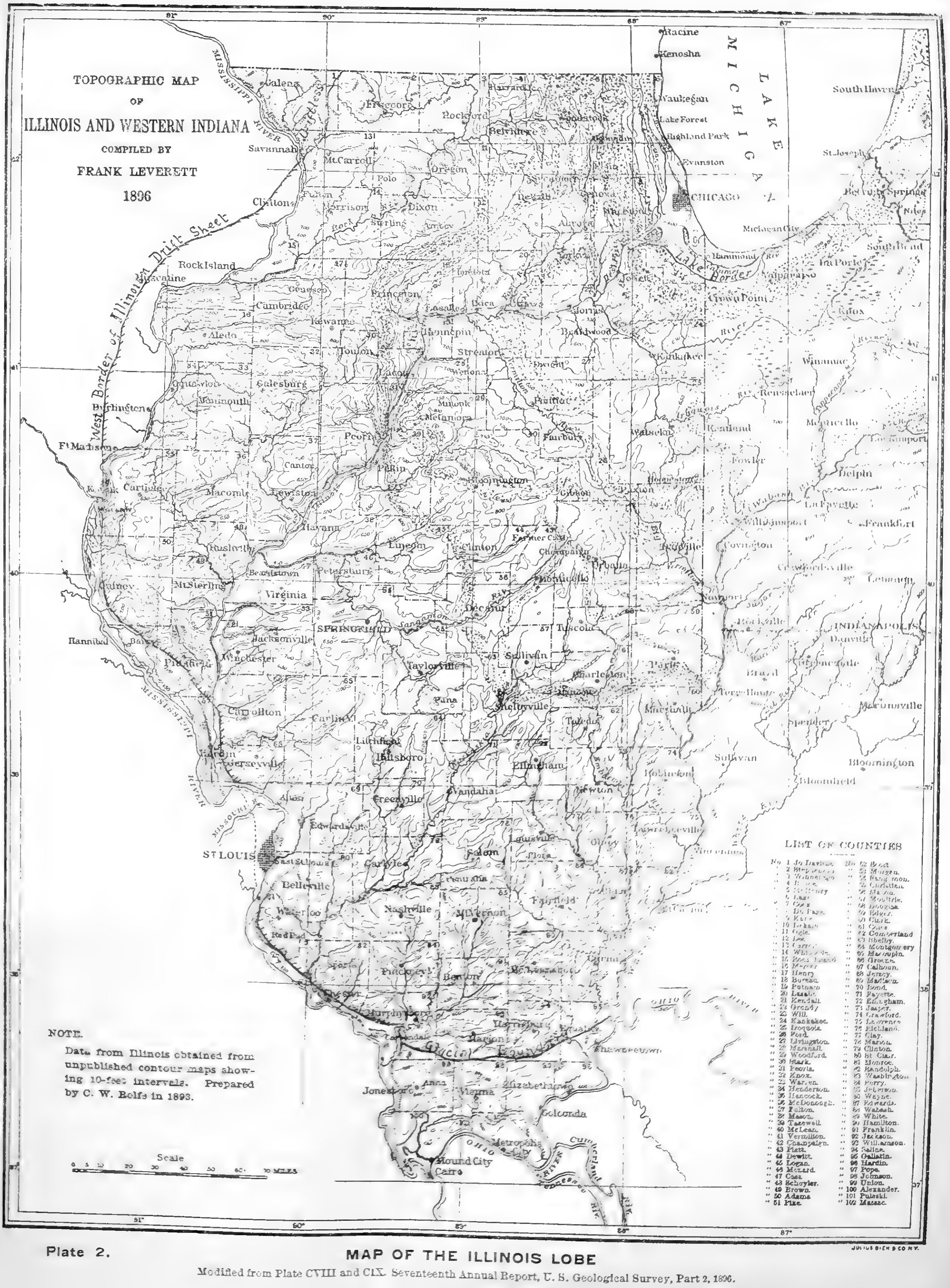


Plate 2.

MAP OF THE ILLINOIS LOBE

Modified from Plate CVIII and CIX. Seventeenth Annual Report, U. S. Geological Survey, Part 2, 1896.

It remains to be determined whether it should be made to include all the drift of Southern Illinois and the oldest sheet of drift in districts to the east from Illinois. Further study is also necessary to determine whether the drift on the border of the Driftless Area in Northwestern Illinois and Southern Wisconsin is so recent as the Illinoian sheet. There may be found in the region referred to a sheet or sheets of drift corresponding in age with one or both of the sheets in Iowa that are earlier than the Illinoian drift sheet. The drift of these regions is thus only provisionally referred to the Illinoian stage.

The Illinoian sheet has in Southeastern Iowa and Western Illinois a variable thickness, ranging from ten feet or less up to fully 100 feet, with an average of perhaps forty feet. It is scarcely so thick as the older sheet of Iowa and Northern Missouri, whose edge it overlaps in Southeastern Iowa. In Southern Illinois, also, the drift is not so thick as in the old sheets of Iowa and Missouri, being even thinner than in Western Illinois. The same is true of the old drift sheets of Southern Indiana and Southern Ohio. In all these districts the older drift is not so thick as the newer. The Illinoian drift sheet has mainly a plane surface, but near its margin there is a tendency to morainic ridging. The ridging is a subdued form, the ridges being one-half to one mile or more in width, with a relief of but twenty-five to fifty feet. The extent of the Illinoian sheet and the distribution of its ridges are shown on the accompanying map (plate 2).

Explanation of Map of Illinois.—In this map the extent of the Illinoian drift sheet is represented. Its extension into Missouri, near St. Louis, is conjectural, but the extension into Iowa is well established. The several moraines formed in the early and late Wisconsin stages are indicated by shading with dots. The extent of Lake Chicago in Northeastern Illinois and Northwestern Indiana is also represented. These features have been added to the map as published by U. S. Geological Survey. The 50 foot contours appear except in the hilly parts of Illinois and in western Indiana where only 100 foot contours are shown.

THIRD OR PRELOESSIAL INTERVAL OF RECESSION OR DEGLACIATION.

There is between the Illinoian drift sheet and the overlying mantle of loess and associated silts a well-defined soil horizon. There is also leaching of the till to depths seldom less than four feet and often much more. It is, therefore, an interval of considerable importance. Its length, however, appears to be somewhat less than that of either of the two earlier intervals.

Prof. Worthen early recognized this soil horizon at the base of the loess and made numerous references to it in the Geology of Illinois. Being situated near the surface, it is much more frequently exposed to view than the soils at lower horizons. Probably, also, it has been subjected to less disturbance and removal than soils which were overridden by the ice sheet.

IOWAN DRIFT SHEET AND MAIN LOESS DEPOSIT.

This sheet of drift was brought to notice by Mr. W J McGee in his early papers on the drift of Northeastern Iowa, where it is commonly referred to as the "upper till." It was found by Mr. McGee to be of the same age as a deposit of loess which covers Southeastern Iowa, but which was excluded from much of Northeastern Iowa by the ice sheet (1).

This drift sheet Mr. McGee found to be markedly different in its stony ingredients from the sheet that underlies it. It is separated from that sheet by a prolonged interval. This interval, it now appears, comprises not only the third or preloessial interval of Western Illinois, but the time covered by the Illinoian stage of glaciation and the deglaciation interval which preceded it. Comprising thus the time of two stages of deglaciation and one of glaciation, the interval shown in Northeastern Iowa is necessarily very marked.

The Iowan sheet is thought to be represented in Northern Illinois by a sheet of drift found mainly east of Rock River, though extending in places west of that stream. This sheet is concealed within a few miles east of Rock River by a later drift sheet (the early Wisconsin).

Both in Iowa and Illinois the sheet referred to the Iowan stage is perceptibly fresher than the sheet of the Illinoian stage of glaciation. The depth of leaching is, on an average, one to two feet less than on the Illinoian drift sheet. The erosion of streams is also less, apparently not more than half as great as in the Illinoian drift sheet.

FOURTH OR POST-LOESSIAL INTERVAL OF RECESSION OR DEGLACIATION.

This interval is shown to be one of considerable length by the amount of valley excavation which occurred between the deposition of the loess and the succeeding stage of glaciation. At the close of the loess deposition the main valleys, such as the Missouri, Mississippi, and Illinois, were filled throughout most

[1] See Eleventh annual report U. S. Geological Survey for a full discussion of this drift sheet.

of their lower courses to heights of 75 to 100 feet, or more, above the present streams. But before deposits from the waters, contributed by the succeeding glaciation, were poured into these valleys, they had been cut down about to the present level of the streams and in some cases, perhaps, to an even lower level.

The cutting down of the valleys indicates a marked change in altitude or at least in attitude of the land surface, and this change cannot have been accomplished in a very brief period.

EARLY WISCONSIN DRIFT SHEETS.

Under this term are included several important morainic systems, which are well displayed in the State of Illinois. The names applied to these morainic systems are in every case taken from Illinois localities. Shelbyville is derived from the county seat of Shelby County, which is situated on the outer belt of moraines. Champaign is from the city of that name in Eastern Illinois, which is situated on one of the principal members of the morainic system to which the name is applied. Bloomington is situated upon the principal member of a still later system of moraines, well displayed in Central Illinois. Marseilles is situated at a point where the moraine to which this name is applied crosses the Illinois River.

It is thought that the several morainic systems just mentioned were formed in comparatively rapid succession in the order named. At least no decisive evidence of a prolonged interval separating the formation of successive morainic systems has been discovered. It is probable that some oscillation of the ice front occurred, so that the moraines do not mark simply halts in the recession of the ice. They may mark the limits of successive advances following retreats of minor importance.

Shelbyville Morainic System.—The Shelbyville morainic system marks the southern limits of a sheet of thick drift, the thickest, perhaps, formed in Illinois at any stage of the glacial period. The distribution of the moraine may be seen by reference to the accompanying map (Plate 2). Whether the outer ridge throughout the entire extent from the Wabash River, near Terre Haute, Ind., around to the Wisconsin line, near Harvard, Ill., was occupied at any one time by the ice sheet, or whether there were oscillations by which some parts were formed earlier than others, is not yet definitely settled. Possibly the outer ridge in the vicinity of the Illinois River should be classed with the Iowan rather than the Early Wisconsin drift. This system has not much relief

above the district lying on its inner or iceward border, since that district was filled with drift nearly to the level of its crest. But on the outer, or landward, border there is usually a relief of 75 to 100 feet or more. Viewed from the outer border, the moraine in places presents the appearance of a bluff or escarpment, though the rise of 75 to 100 feet usually occupies a mile or more.

By reference to the map, it will be seen that there is a feeble morainic belt lying a few miles back from the border of this drift sheet. This is included with the Shelbyville system. It seems to mark a brief halt of the ice sheet soon after it began its retreat.

The main moraine, though very bulky, has but little surface expression, much of it being nearly as smooth as the plains to the north. It consists mainly of a single ridge, but in Edgar and Coles Counties it has in places a double ridge. The feeble belt just referred to presents in places a sharper morainic expression than the main moraine, there being clusters of sharp knolls rising abuptly thirty to fifty feet, or more, above border tracts. The greater part of this belt, however, has a gently undulating surface, like that of the main moraine.

This sheet of drift, terminated by the Shelbyville moraine, is composed in the main of a soft, fresh-looking, blue till, markedly in contrast with the partially cemented brown and gray tills which underlie it, and extend southward into the outlying districts. It has long been recognized by well-drillers as a sheet very distinct from the underlying tills. From the Shelbyville moraine a sheet of soft blue till, similar to that in the moraine, is found beneath plains, as well as moraines northward over much of Northeastern Illinois. There appears to be but little difference in the structure of drift in the morainic ridges from that in plane-surfaced tracts.

Champaign Morainic System.—The Champaign morainic system, though far less bulky, is fully as complex as the Shelbyville system. It consists of several more or less distinct members separated by plains, the latter ranging in width from a mile or less up to three and even five miles. It is exposed to view only in Eastern Illinois, being combined with or overridden by the Bloomington system from the vicinity of Bloomington westward. It is poorly developed in Indiana, though small ridges are traceable across Vermillion, Parke and Fountain Counties to Montgomery County, Indiana, where they are overridden by a morainic system of the Late Wisconsin stage. The complexity of the system and the distribution of its several members may be seen by reference to the accompanying map (Plate 2).

Where best developed the members of this morainic system have a relief of fifty to seventy-five feet above plains on the outer border, but, like the Shelbyville system, the relief is less pronounced on the inner border. In Indiana the belts have less relief, seldom more than thirty or forty feet. Where best developed, the members of this morainic system are one to two miles in width. The surface is usually strongly undulating, a feature which distinguishes the moraines from the bordering nearly level plains. The surface expression is on the whole stronger than in the Shelbyville moraine.

In structure this morainic system does not differ markedly from the Shelbyville system. The ridges are composed mainly of a soft till. The soft till extends to a level somewhat lower than the base of the ridges, a feature which is thought to indicate that the Shelbyville drift is here present in considerable thickness. Beneath the soft till of the Shelbyville drift a black soil is found, which forms the surface of a drift older than the Shelbyville, presumably the Illinoian drift sheet.

Bloomington Morainic System.—This is a more prominent morainic system than the Champaign. It is traceable from Western Indiana westward across Central Illinois in a somewhat indirect course (with a re-entrant angle near Gibson City) nearly to the Illinois Valley. Whether this system crosses the Illinois just above Peoria and becomes combined with an earlier system, or has its continuation in certain local developments of morainic topography along the east side of the Illinois, northward to the bend near Hennepin, is not fully determined. It is thought that the moraine leading from the bend of the river northeastward and passing near Mendota and DeKalb belongs to this system. At the east this system is overridden by a later moraine in Benton and Warren Counties, Indiana.

The portion east from the Illinois River has, in places, three, and elsewhere two well-defined members separated from each other by narrow plains. The outer member of the system has generally a relief of 75 to 100 feet above plain tracts south of it, thus approaching in strength the Shelbyville system.

In structure the drift of this morainic system closely resembles that of the two systems outside of it, being chiefly a soft blue till. It rests upon a soft till, which is thought to be the northward extension of the Shelbyville sheet. This in turn is underlain by a hard till, probably of the Illinoian stage.

The topography is of a swell and sag type, rather more pro-

nounced than in either of the earlier systems of the Early Wisconsin stage. The undulations not infrequently extend back for several miles on the inner border of the morainic system and fade away gradually into characteristic till plain topography.

Marseilles Morainic System.—The Marseilles morainic system consists of a bulky ridge, usually with a single crest, but in places double, which encircles the basin at the head of the Illinois River, known as the Morris basin. From the north border of the basin it extends northward along the east side of Fox River to the vicinity of Elgin, beyond which it has not been separated from the moraines of the Late Wisconsin stage. At its southeastern end, also, this moraine is concealed by a moraine of the Late Wisconsin stage.

Aside from the main belt, called the Marseilles, there is a small moraine, the Minooka, which separates from the Marseilles moraine near Oswego, Ill., and passes southward into the basin at the head of the Illinois. It has not been recognized south of that stream. This moraine probably followed closely the Marseilles moraine in its deposition, and is accordingly included in the Marseilles system.

The Marseilles moraine stands 50 to 100 feet above the plain on its outer border and even higher above the basin on its inner border. Its inner border relief is much more marked than that of any of the morainic systems yet discussed. This is due largely to the thinness of the drift deposits on the inner border, there being a much smaller amount of drift there than on the inner border of the other morainic systems.

The surface expression of this moraine is very similar to that of the Bloomington system, the topography being of a sharply undulating swell and sag type. The Minooka moraine is much smoother surfaced than the Marseilles and has a relief scarcely half as great.

The structure of the drift, both in the Marseilles and the Minooka moraine, is similar to that in the other morainic systems, being chiefly a soft blue till.

FIFTH INTERVAL SHOWN BY SHIFTING OF ICE LOBES.

The evidence for this interval is based largely on the change of front or shifting in the position of the ice lobe which invaded Northeastern Illinois and districts to the north and east. It is best shown in Western Indiana, where the moraines of the later stage cross those of the earlier one at a high angle. It is thought

that this change of front could not have taken place in a brief time.

In connection with this change of front there appears a remarkable increase in the number of surface bowlders, a feature which may prove to have great significance. The causes for variations in the number of surface bowlders are so little understood as yet that we scarcely are warranted even in conjecturing the import of such bowlder belts. They may signify a great recession of the ice sheet, followed by a fresh advance across the Canadian highlands, by which a new supply of bowlders was gathered up and brought down to the extreme limit reached by that advance. Such bowlders in some cases, as recently suggested by Mr. F. B. Taylor (1) may be derived from accumulations in interglacial valleys. This suggestion, however, can scarcely apply to bowlder belts of such length as are displayed in Western Indiana and Eastern Illinois.

LATE WISCONSIN DRIFT SHEETS.

The moraines of the Late Wisconsin series contain generally a larger amount of assorted material with the till than is found in the moraines and accompanying till sheets of the Early Wisconsin series. The topography also is more closely allied to the knob and basin type than to the gently undulating broad ridged type of the Early Wisconsin series.

Some attention has been given the subject of comparative amounts of surface leaching and erosion on the Marseilles moraine and the moraines of the Late Wisconsin series, but no striking contrast has been observed. A more refined investigation, however, may bring to light essential differences.

Great Bowlder Belts and Accompanying Moraines.—The bowlder belts of Northeastern Illinois and Western Indiana have attracted attention from the earliest days of exploration, as have also their continuation in Central and Eastern Indiana and Western Ohio. In the early explorations they were observed only as detached belts, but their connections are now well established. Occurring, as the bowlders usually do, in narrow, well-defined belts, they are readily traced from section to section, even where unaccompanied by peculiar topographic features. Throughout much of their course in Ohio and Indiana these bowlder belts are simply an accompaniment of well-defined belts of morainic drift. But in Western Indiana and Northeastern Illinois the bowlder

[1] In a paper presented at the Washington meeting of the Geological Society of America, December, 1896.

belts often cross smooth plains having only occasional developments of morainic topography.

The moraines which these bowlder belts accompany are usually a strong phase of the swell and sag type bordering on the knob and basin type. They are moraines which in their northward continuation in Eastern Wisconsin assume a pronounced knob and basin type.

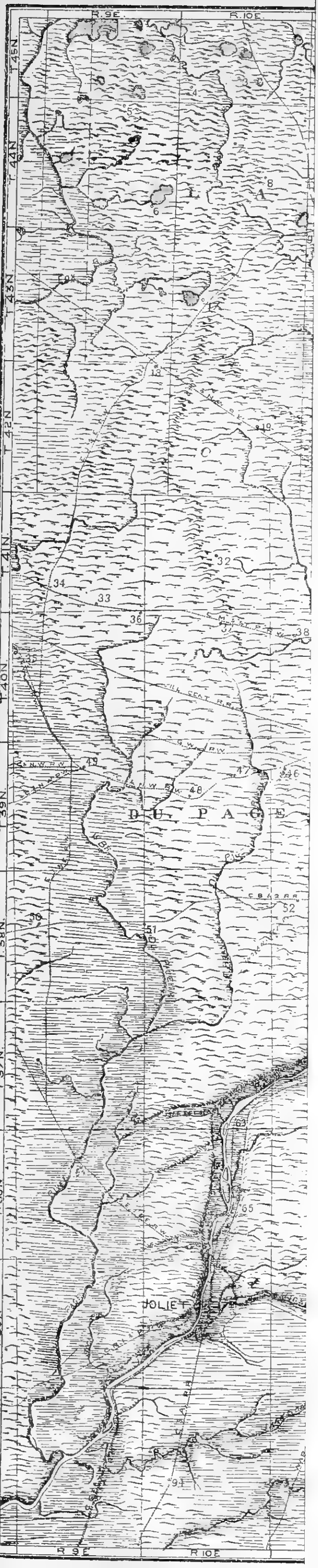
In northern Kane and McHenry Counties there are bulky moraines with strong expression, which do not have definite southward continuation, unless it be in the bowlder belts. It is not certain whether they are to be correlated with the much feebler, bowlder strewn moraines of Eastern Illinois and Western Indiana, with which the bowlder belts give them a possible connection. They may prove to belong to the Early Wisconsin series. In that case they were overridden without being obscured by the very bowldery drift sheet.

Valparaiso Morainic System —This system consists of a more or less complex belt, which sweeps around the head of Lake Michigan, passing through the western and southern part of the Chicago Area. It receives its name from the city of Valparaiso, Ind., situated on its crest. As it is fully discussed on subsequent pages, further description at this point is unnecessary.

Lake Border Morainic System.—This system embraces a series of till ridges well displayed along both the western and eastern borders of Lake Michigan. Those in Lake and Cook Counties, Illinois, are discussed in detail in this paper. Similar ridges appear in Porter and Laporte Counties, Indiana, and in the western counties of Michigan as far north as investigations have been carried (to the mouth of Kalamazoo River).

THE LAKE BEACHES.

Upon the retreat of the ice sheet from the head of Lake Michigan a body of water collected in the southern end of the basin and discharged southwestward by the "Chicago outlet" to the Desplaines River. This period of discharge appears to have been followed by a period in which the water level was too low to discharge in that direction. There then succeeded another period of discharge through the southwestward outlet. This period of discharge was followed by the present lake stage with northward outlet. As this complicated lake history is discussed in some detail farther on, it is left here with this passing word.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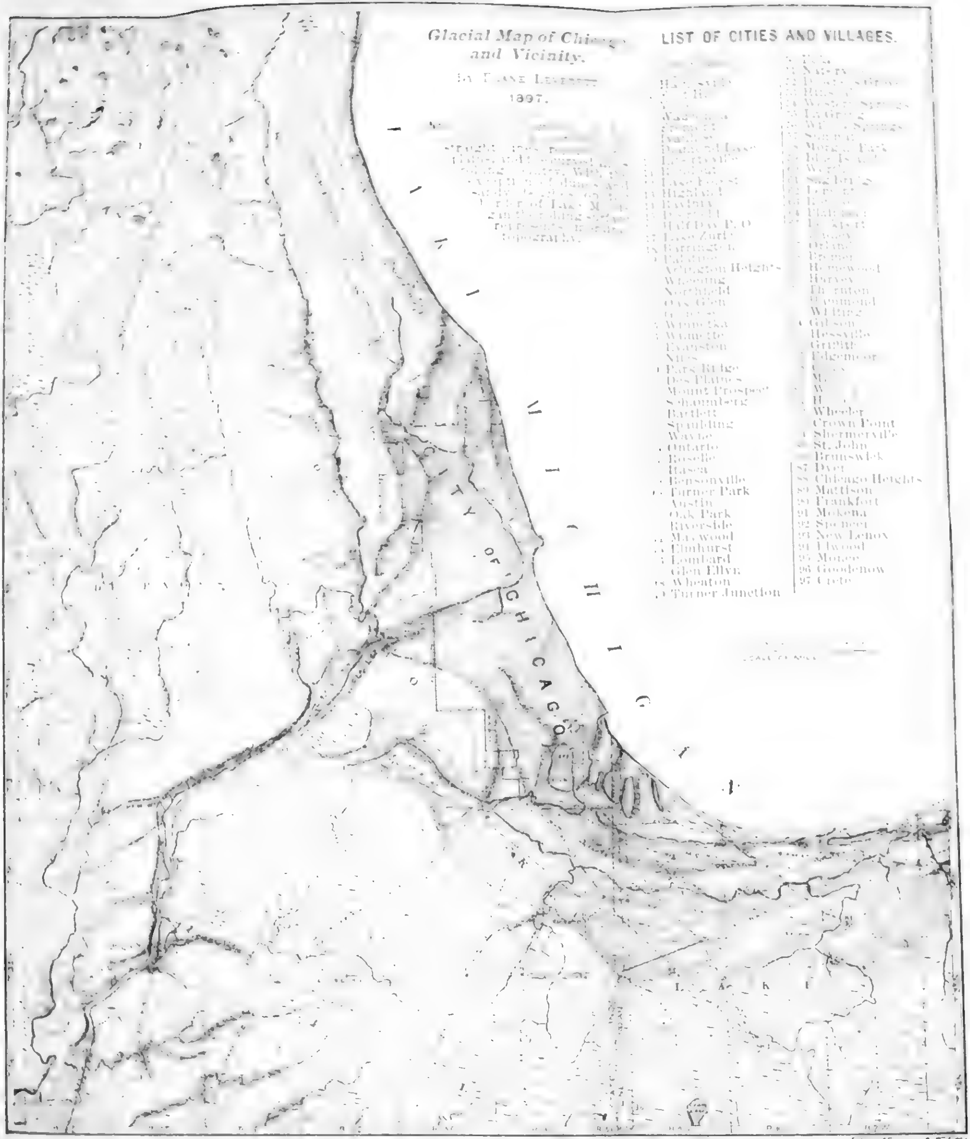

Plate 3. MAP OF THE CHICAGO AREA.

GENERAL PHYSIOGRAPHIC FEATURES OF THE CHICAGO AREA.

The principal physiographic features of the Chicago Area were produced by the ice sheet, the rock surface being generally covered to a great depth by the drift. The variations in altitude which the region presents are produced by inequalities of drift accumulations rather than by the underlying rock, the elevation of the rock surface being but little, if any, higher in the highest parts of the area than it is in the lowest.

The most conspicuous physiographic features are the lake plain, the lake outlet, and the Valparaiso moraine. Less conspicuous features are found in the Lake Border Morainic System of northern Cook and eastern Lake Counties. These are each discussed in some detail farther on, but a brief outline of their features may be of service at this point.

The lake plain has its most extensive development in Chicago and its immediate borders as far north as Winnetka. It extends back some twelve to fifteen miles from the lake, with a general southward and westward rise, the elevation averaging about ten feet at the border of Lake Michigan and about fifty feet at the upper beach. This plain is continued into Indiana, but is greatly concealed by dunes. North from Waukegan there is a narrow plain bordering the lake, whose elevation is but twelve to thirty feet above the present lake level.

The portion of the shore of Lake Michigan between Winnetka and Waukegan is occupied by one of the ridges of the Lake Border morainic system, and the erosion of this ridge by the lake gives the high banks which are present in that section. Between this ridge and the Desplaines River there are a series of till ridges separated by narrow plains. The ridges rise to a height of 100 to

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Explanation of Glacial Map of Chicago and Vicinity.—On this map an attempt is made to give a bird's-eye view of the area by means of broken profiles. The moraines appear with undulating contour, the plains with straight lines, the beaches with abrupt, step-like descent of the plain. Striae are indicated by arrows and represent bearings accurately. Some confusion of dunes with moraines may arise if it is not borne in mind that the belt of ridges bordering Lake Michigan in Lake County, Indiana, consists of sand dunes. The dunes are found for eight to twelve miles south from the lake in that county. The bars in Cook County, Illinois, also are to be distinguished from the moraines. They are much lower and narrower ridges, as shown in the discussion.

125 feet above the lake and the plains from 60 to 90 feet or more. The general elevation is, therefore, higher than in the lake plain bordering the city of Chicago.

The district between the Des Plaines and Fox Rivers in Lake, northwestern Cook and Du Page Counties, is largely occupied by the Valparaiso moraine. This moraine is interrupted by the Chicago outlet in southwestern Cook and northern Will Counties. East from this outlet it is developed along the watershed between the Kankakee River and Lake Michigan in southern Cook and eastern Will Counties and continues thence eastward, swinging gradually to the north around the head of Lake Michigan.

The highest points on the Valparaiso moraine are found in southern Lake and northwestern Cook Counties. One of these, just east of the village of Volo, stands 913 feet, and one in the northwest section of Cook County stands 910 feet above tide, as determined by the Barometric survey under Professor Rolfe. Much of the crest of the moraine in the southwestern part of Lake County rises above 850 feet. In northwestern Lake County and in northwestern Cook County it rises generally above 800 feet and a few points exceed 850 feet. In Du Page County the crest is generally about 750 feet. In Will County a few points rise above 800 feet, but the general elevation is not much above 750 feet, and this elevation is maintained eastward about to Valparaiso, Ind., where the moraine rises above 800 feet and continues with an elevation of 800 to 900 feet from that point to the borders of the St. Joseph River in Michigan.

From the Valparaiso moraine there is less descent toward the Fox River Valley than toward Lake Michigan, the elevation of the immediate border of the valley being 750 to 775 feet in Lake County and 700 to 750 feet on the borders of Cook and Kane Counties. But upon approaching the Des Plaines River the district outside the moraine becomes about as low as that along the lake, and the immediate valleys of the Des Plaines and Kankakee, in Will County, are lower than the lake surface. Farther east the district outside the moraine reaches an elevation higher than the lake level, the altitude of the Kankakee marsh at the

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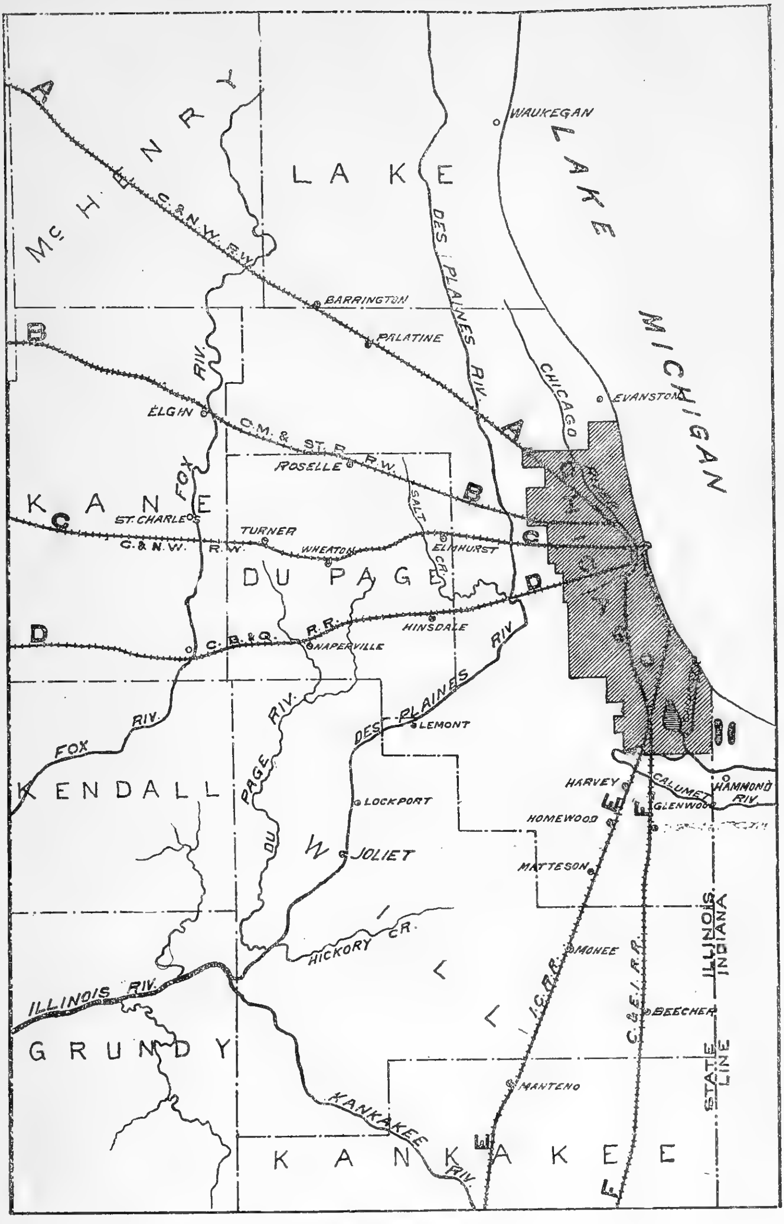
Explanation of Profile Sections.—The profile sections given in Plate 4 are based upon the railway surveys along six lines radiating out from Chicago. The distance to rock is shown by a series of well borings along each line. In cases where rock is not struck the depth of well is indicated. The vertical scale being about thirty times the horizontal, the reliefs of the region are sufficiently well outlined to be readily seen.



INDEX MAP
SHOWING
LINES OF PROFILES

Vertical Scale 30 times the horizontal.

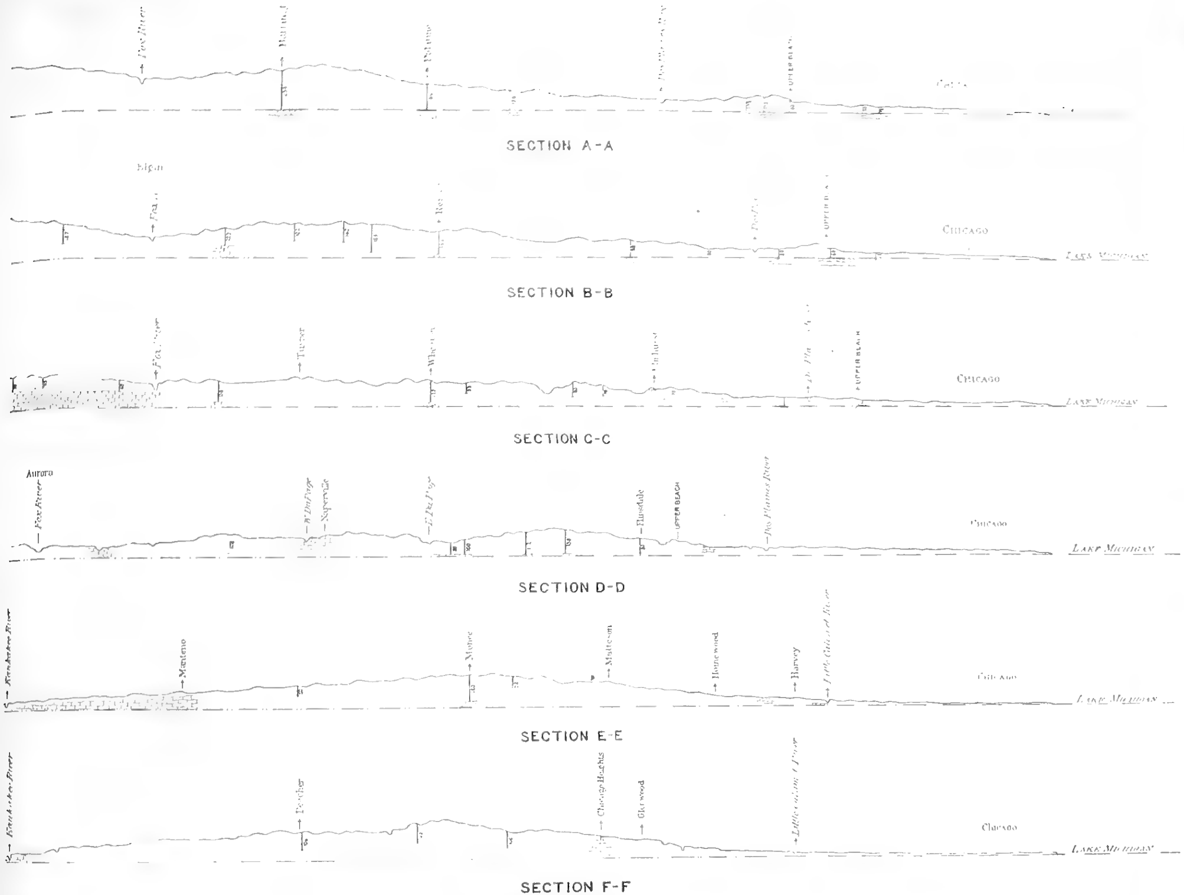
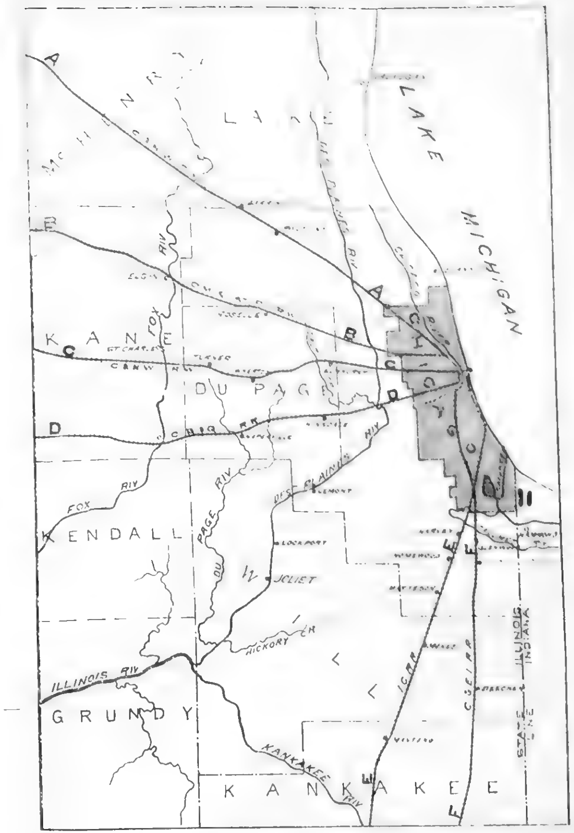


Plate 4.

PROFILE SECTIONS RADIATING OUT FROM CHICAGO.



INDEX MAP
SHOWING
LINES OF PROFILES

Length of each Profile 45 miles. Vertical Scale 30 times the horizontal.

State line being about forty to fifty feet, and its eastern end, near South Bend, fully 100 feet higher than the lake.

The lake outlet trenches the Valparaiso moraine to a level about as low as the surface of Lake Michigan, with a valley nearly a mile in average width. This is the only drainage line crossing the Valparaiso moraine in Illinois and no drainage line crosses the moraine in Indiana, though it is crossed by the St. Joseph River just north of the Indiana line between Niles and Berrien Springs in Michigan.

Some of the features just discussed are well represented on the reduced topographic map accompanying this paper. But the large map sheets of the United States Geological Survey should be consulted for the full representation of characteristic features of the plain, the outlet, and the Valparaiso moraine. It is to be hoped that the map sheets of the entire State, which Professor Rolfe has prepared, may soon be published, since they bring out clearly the main physiographic features.

THE VALPARAISO MORAINE IN ILLINOIS.

THE MORAINE.

Distribution.— At the Illinois and Wisconsin line and for some thirty miles southward the Valparaiso moraine is so closely associated in its outer or west border with earlier moraines that that border is not clearly outlined. Just south of Elgin the moraine first becomes distinct, its course there becoming east of south, while the earlier moraines bear west of south. It covers the lake region of western Lake and eastern McHenry Counties, its eastern border in Lake County being nearly coincident with that of the system of small lakes, and slightly east of the water parting between the Fox and Des Plaines Rivers.

In Cook and Du Page Counties the moraine has a breadth of not less than ten miles and in places reaches fifteen miles, its inner border being somewhat irregular. In northern DuPage County it lies entirely within the limits of the county, but farther south it encroaches on western Cook County, the inner border at the Des Plaines River being about four miles east of the county line. The outer border from Wayne to Turner Junction lies just east of the Chicago and Northwestern railroad. South from Turner Junction the West Du Page River follows the border. In southern Du Page County there is a separation into rudely parallel ridges between which are lowlands, which are utilized by the southward flowing streams, East Du Page River and Salt Creek. Near the south part of Du Page County the East Du Page is forced to turn westward into the West Du Page, for the ridges which are separate in Du Page County coalesce in northern Will County. Salt Creek has, in its lower course, left its old valley and cut a new one eastward through Proviso Township, Cook County, to the Des Plaines. The old valley passes southward through the western part of Lyons Township, almost in line with the upper portion of Salt Creek Valley, crossing the Chicago, Burlington and Quincy Railway west of Western Springs, and joining the Des Plaines about seven miles below the present mouth of the creek.

Through Will and southern Cook Counties the moraine has a southeasterly course. Its inner border is nearly parallel with

the shore of Lake Michigan and distant from it about twelve miles. The Des Plaines River enters this moraine near Mt. Forest and the other lake outlet, known as "the Sag," enters it about five miles east of Sag Bridge. Between Mt. Forest and the Sag outlet the moraine covers an island situated between the outlets of Lake Chicago. The main part of the moraine crosses the Des Plaines between Lemont and Joliet and thence, continuing south of east, its crest passes near Frankfort and Monee and enters Indiana from southeastern Will County. There is a somewhat distinct outer belt following the divide between the Des Plaines and Du Page southward past Joliet and crossing the Des Plaines three to five miles below that city. This belt, east from the Des Plaines, is in places distinct from the main belt, but scarcely merits a separate name, since it is so generally united with that belt. Where distinct it is about two miles in width. Throughout much of the interval between the Des Plaines and the Indiana line this outer belt is nearly parallel with the Kankakee River and distant from it about ten miles. Near the Indiana line its border approaches the Kankakee and in Indiana follows closely the north side of the marsh drained by the Kankakee.

Relief.—The crest of the Valparaiso moraine is much higher than its outer and inner borders, but the moraine has such broad slopes that it has not a bold relief on either face. The following table of elevations is taken from the profiles of several of the railways which cross the moraine.

TABLE OF ELEVATIONS ON VALPARAISO MORAINE.

Railroad.	Inner Border.	Crest.	Outer Border.	
E. J. & E., in Lake County	720 feet.	880 feet.	770 feet.	
Wisconsin Central	683 "	823 "	778 "	
C., M. & St. P.	646 "	812 "	768 "	
C. & N. W. (Wis. div.)	650 "	867 "	772 "	
C. & N. W. (Omaha div.)	641 "	760 "	750 "	
C., B. & Q.	646 "	763 "	700 "	
Wabash	665 "	712 "	680 "	(1)
C., R. I. & P.	630 "	725 "	680 "	(1)
Ill. Central	650 "	806 "	710 "	
C. & E. I.	632 "	777 "	713 "	

(1) Outer border of main ridge.

All of the above lines cross the highest part of the moraine in their respective latitudes, except the Wabash, Chicago, Rock

Island and Pacific, and the Omaha division of the Chicago and Northwestern. These lines cross low points in the crest, twenty-five to fifty feet lower than the general altitude of neighboring portions. The highest parts of the crest in Illinois, as noted above, are in northwestern Cook and southwestern Lake Counties, and stand about 900 feet above tide.

Surface Contours.—The Valparaiso morainic system presents notable variations in surface contour, even in the short section that lies within the State of Illinois. At the north, in Lake County, there are numerous basins occupying an area ranging from a few acres up to several square miles each, and containing lakes or marshes. They are scattered over the slopes of the moraine, indenting its surface to depths of twenty-five to fifty feet or more. Basins become rare upon passing southward into Cook County and the moraine is comparatively free from them throughout the remainder of its course in Illinois. The few which occur are very small and shallow. These basins, with their lakelets, add greatly to the beauty of the scenery of Lake County, furnishing attractive sites for summer residences and for camping grounds. Among the lakes there are knolls and irregular ridges, with gentle slope, ranging in height from ten feet or less up to about fifty feet. The moraine has also a well-defined crest line in a ridge twenty to forty feet higher than the border tracts and a mile or less in width, which leads southward, with a somewhat winding course, through the western part of Lake County, forming the water parting between Fox and Des Plaines Rivers.

Passing south into Cook County the crest line continues as definite as in Lake County. To the east of the crest line there are only gentle swells seldom more than fifteen feet in height and a rapid descent to the plain bordering the Des Plaines. To the west of the crest line there is an irregular network of ridges and knolls, inclosing winding sloughs. The height of these knolls and ridges ranges from ten or fifteen feet up to fully fifty feet. Continuing south across Du Page County the ridges tend to a parallelism with the crest and the sloughs become less conspicuous. This topography also characterizes the portion of the moraine in Will County. In the latter county the tendency to a parallel arrangement of the ridges and of chains of knolls is very marked. Throughout the course in Du Page and Will Counties the inner slope has a milder expression than the crest or outer slope, though the contrast is scarcely so striking as in Cook County.

The outlying belt in Will County carries low knolls twenty

feet or less in height. There is not so well-defined ridging as in the main belt. Though the undulation is not sharp, it is sufficient to give this belt a strong contrast to the very smooth till plain which borders it on the south. The contrast with the till plain on the north is not so striking, for that plain is dotted with low swells ten feet or more in height.

Thickness of the Drift.—Situated as the Valparaiso moraine is in a district over which there have probably been several successive ice advances with intervening recessions, the drift can scarcely be expected to belong solely to the advance which formed this moraine. It is known that remnants of the partially cemented sheets of the oldest stages of glaciation are present. There is probably present also a considerable amount of drift of the Early Wisconsin stage. The drift of the Early Wisconsin stage is so similar to that of the Valparaiso moraine that it is doubtful if it can be readily distinguished from it. There does not appear to be a well-defined soil horizon at the base of the Valparaiso sheet to mark the line of junction such as occurs under wide areas at the base of the Early Wisconsin drift. The thickness of the Valparaiso drift sheet can perhaps be best estimated by the relief, for it can scarcely be assumed to exceed greatly the measure of the outer border relief of the moraine. The relief on that border is estimated to average about sixty-five feet. The average thickness is probably even less than the relief, since the sheet is markedly thinner on the borders of the moraine than on its crest.

The combined thickness of the several sheets of drift here represented is also difficult to determine from the fact that the underlying rock surface is very uneven. In Cook County alone the rock surface is known to range from about 100 feet above the level of Lake Michigan to more than 100 feet below the surface of the lake. In the table of thickness of drift which follows, the older deposits as well as those of the Valparaiso moraine are included.

List of deep borings along the Valparaiso Moraine in Lake, Cook, Du Page and Will Counties:

		Thickness of Drift.		Approximate Elevation above Tide.	
1.	At Ivanhoe, on crest	290	feet	800	feet
2.	Near Lake Zurich, on crest	267+	"	900	"
3.	At Lake Zurich, 20 to 30 feet below crest	240+	"	880	"
4.	Hainesville, near crest	287+	"	880	"
5.	Gilmer, near crest	213+	"	820	"
6.	Crest, east of Wauconda	230+	"	850	"
7.	Crest, south of Barrington	315+	"	850	"
8.	Barrington, 40 to 45 feet below crest	254	"	818	"
9.	East of Elgin, near crest	220-240	"	850	"
10.	Palatine and vicinity	100-170+	"	750	"
11.	Near Schaumberg, along crest	190+	"	825	"
12.	Arlington Heights, about 150 feet below crest	128	"	700	"
13.	North of Arlington Heights, 20 to 30 feet above station	190	"	725	"
14.	Near Spaulding, about 50 feet below crest	120	"	770	"
15.	Bartlett, 10 to 20 feet below crest	100+	"	800	"
16.	Ontarioville, near crest	140+	"	815	"
17.	Roselle, about 50 feet below crest	100+	"	770	"
18.	Crest south of Bloomingdale	162	"	800	"
19.	Itasca	72+	"	692	"
20.	Bensenville	97	"	677	"
21.	Elmhurst	98	"	688	"
22.	Elmhurst Quarry	Trace		660	"
23.	Turner Junction	116	"	765	"
24.	Quarries near Naperville	Trace		700	"
25.	Crest east of Naperville	115+	"	740	"
26.	Downers Grove	113+	"	720	"
27.	Crest east of Downers Grove	159	"	750	"
28.	Near Clarendon Hills	160+	"	755	"
29.	Crest northwest of Lemont	150	"	740	"
30.	Crest of moraine east of Lockport	115+	"	725	"
31.	Near Spencer	81	"	710	"
32.	Crest near Frankfort	135+	"	780	"
33.	Hickory Creek, near Frankfort	Trace		730	"
34.	Sec. 13, Tp. 35, R. XII E	"		760	"
35.	Monee, on crest	180+	"	804	"
36.	Crest near Goodenow	112+	"	780	"
37.	Beecher	106+	"	720	"
38.	Sec. 11. Tp. 34, R. XIV E	106+	"	720	"
39.	Chicago Heights	30	"	690	"
40.	Quarry 1 Mi. east of Chicago Heights	Trace		665	"

Structure.—The drift of the Valparaiso sheet, together with that of the Early Wisconsin, which underlies it, consists mainly of a soft blue till, easily penetrated by the spade or auger. With the till there are local deposits of sand or gravel, which collect the water that supplies wells. There are also a few places in which the deposits of sand and gravel occupy nearly the entire drift section. In following the moraine through Northeastern Illinois there will be found occasional townships in which the till, which is a poor source for water because of its compact matrix, is not accompanied by a sufficient amount of sand or gravel to furnish water for strong wells, while in adjoining townships no difficulty may be experienced in obtaining water. It is more often found necessary to drill wells to great depths in eastern and northern Du Page, northwestern Cook and southern Lake Counties than elsewhere along the moraine in Illinois, many wells in that district being more than 150 feet in depth. In southern Du Page County, between the east and west branches of Du Page River, the drift to a depth of fifty to sixty feet or more (the depth reached by the deep wells) is mainly sand and gravel, this being an unusually gravelly part of the moraine. In Will County wells seldom reach a depth of 100 feet because of the abundance of water-bearing sand or gravel at less depth.

In collecting well records there is, I find upon examining my notes, a larger proportion showing exceptional than normal conditions, it being natural to pass over the usual section after it is once noted without collecting further records. This should be borne in mind when examining the specific well records given below. Scores of wells were found which show a section about as follows: At surface ten to twelve feet of pebbly yellow till, beneath which is a soft blue till extending to the water bed of sand or gravel at depths ranging from twenty-five feet to 150 feet or more. If a well is carried to a depth much beyond 150 feet it is usual to pass out of the blue till into a hard brown till, unless rock is reached. This hard till presumably belongs to one of the earliest invasions of the ice. In a few cases great depths of sand have been found beneath the blue till, as noted below. The sections of wells here given include the deepest which came to my notice.

S. J. Lewis, a well driller, of Elgin, Ill., reports a well about one mile east of Lake Zurich, in Lake County (in Sec. 20, T. 43 N., R. 10 E.), which has the following section:

1. Yellow, pebbly clay	12 feet
2. Grayish-blue, pebbly clay	88 "
3. Fine, gray sand	197 "
Depth	297 feet

Altitude of well mouth about 900 feet A. T.

Mr. Lewis reports three wells near Lake Zurich which obtain water in gravel beneath the blue till at 138, 140 and 150 feet, respectively. Near Hainesville, in Sec. 28, T. 45 N., R. 10 E., he reports a boring to have reached the bottom of the blue till at 120 feet. Below this till is sand for a depth of 167 feet. The sand yielded an abundance of water, but was too fine to be screened by the strainer and no well could be obtained. Near Gilmer, in Sec. 3, T. 43, R. 10 E., Mr. Lewis made a well which penetrates stony clays 120 feet and sand 93 feet, obtaining water in coarse sand at a depth of 213 feet. For a mile or more east of Gilmer wells are obtained in gravel beneath blue till at a depth of 75 to 100 feet, but occasionally the blue till extends to a depth of 160 feet. In Barrington Township, Cook County, T. 42 N., R. 9 E., wells usually penetrate soft blue till to a depth of 100 to 140 feet and occasionally 200 feet before reaching a water bearing gravel or a harder till.

Mr. W. Spumer, of Lake Zurich, who has had some experience in boring tubular wells, furnished the following section of his own well near Lake Zurich, in Sec. 17, T. 43, R. 9 E.:

1. Yellow, pebbly clay	10 feet
2. Grayish-blue, pebbly clay, about	130 "
3. Sand, and blue, pebbly clay in alternate layers of various thicknesses	60 "
4. Sand, becoming coarse and gravelly at bottom	43 "
Depth	240 feet

Mr. Spumer reports that a boring at Ivanhoe, Sec. 22, T. 44, R. 9 E., strikes rock at 290 feet. A well three miles southeast of Wauconda, on the Fletcher Estate, Sec. 32, T. 44, R. 10 E., is reported by Mr. Spumer to have the following section:

1. Yellow, pebbly clay	12 feet
2. Gravel	2-3 "
3. Blue, pebbly clay, with sand pockets	100 "
4. Sand and reddish, pebbly clay, in alternate layers, each 10—15 feet	107 "
5. Whitish, sandy clay	4 "
6. Sand and gravel	3 "
Depth	230 feet

Mr. Spumer estimates the depth of the blue till along the divide between the Fox and Des Plaines Rivers in southern Lake County to be 125 to 150 feet and wells occasionally obtain water in gravel immediately beneath this till.

Mr. William McWendle, a well borer at Oak Glen, reports two wells at Barrington that strike rock at 254 and 250 feet, respectively. To a depth of about 160 feet in each well the drift is mainly a soft blue till. Considerable cobble was encountered at this depth. Below the cobble is a lighter colored clay harder and more pebbly than the blue clay and apparently belonging to an older drift sheet.

Mr. A. W. Van Dervolgan, of Batavia, reports the following section of a boring on the crest of the moraine south of Barrington, in Sec. 22, Barringtown Township, which is the thickest section of drift yet noted in the Chicago Area:

1. Yellow and blue, pebbly clays, about	160 feet
2. Quicksand, about	15 "
3. Reddish, pebbly clay, hard and dry, about	140 "
Depth	315 feet

The well was abandoned without reaching the bottom of the drift and a second boring was made only five rods distant from it, which furnishes a good supply of water at 170 feet.

Mr. M. Sneible, of Palatine, has found in his experience as a well borer that the yellow surface clays in the vicinity of that village vary in depth from six to fifteen feet and that the blue bowlder clay is 100 to 125 feet in depth. He usually finds sand or gravel beneath the blue clay and here obtains the wells, but occasionally a thin bed of cemented gravel is penetrated or limestone is entered just below the blue clay before obtaining a well. In several instances he has reached the bottom of the drift at 150 to 165

feet and in one place, near Palatine, at 100 feet. But it should be borne in mind that the surface elevation in the vicinity of Palatine is at least 100 feet below the crest of the ridge in Barrington Township. Mr. Sneible has found buried soil but once. This was near Arlington Heights, beneath blue bowlder clay, at a depth of seventy feet. The soil was underlain by a pebbly clay. It contained bits of wood and was of an offensive odor.

Mr. R. Ryan, of Bloomingdale, in an extensive experience as a well borer, has found a buried soil but a few times. He recollects its depth in but one instance, in a well in the northwestern part of Schaumberg Township. It occurs at 135 to 139 feet below the surface. It is of a brownish black color and has an offensive odor. It is overlain by blue bowlder clay and underlain by quicksand. Mr. Ryan and also other well borers have found wood and peaty deposits imbedded at slight depth beneath ponds. They are covered by swamp muck and pebbleless clays and have probably been buried in postglacial times. Mr. Ryan reports the soft blue till to have a depth of 100 to 140 feet in the vicinity of Bloomingdale, Schaumberg and Wheaton.

Mr. Diebold, a well borer at Downers Grove, reports a depth of 100 to 115 feet of blue bowlder clay in the vicinity of Downers Grove, Clarendon Hills and Hinsdale. Mr. Diebold furnished the following section of a well at a brick yard on the crest of the moraine three miles east of Downers Grove:

1. Yellow clay (pebbly)	7 to 8 feet
2. Grayish-blue, pebbly clay	112 "
3. Fine, blue sand	39 "
4. Limestone	40 "
Depth of drift	159 feet

Mr. Diebold has frequently found a blue sand beneath the blue bowlder clay in that vicinity, and if this is not present there is usually white sand or gravel beneath the blue clay and overlying the rock.

Borings near East Du Page River strike rock at 100 feet or less, and the sand and gravel which underlie the blue clay are but a few feet in depth.

The structure of the drift along the bluffs of the Des Plaines is well exposed at several points between Lemont and Joliet. There appears to be much more sand and gravel than is shown by well sections on the uplands. There is, however, considerable

till exposed in the east bluff. Just below Lemont a blue till rests immediately on the limestone, but frequently in that locality there is sand or gravel at the base of the drift. In the west bluff, opposite Lemont, there are large accumulations of sand, gravel and cobble, in portions of which bowlders and bowlderets are imbedded, while in other portions assorting is quite perfect. There are also places where a very fine, partially cemented, sand, almost as fine as loess, caps the deposit.

In the portion of the moraine east of the Des Plaines River the yellow clay has a depth of about ten feet. It is underlain by a grayish-blue bowlder clay, which carries a sufficient number of water-bearing veins to furnish abundance of water for wells. There is less difficulty experienced in getting good wells at slight depth here than in the portion of the moraine west of the Des Plaines River. There are very few tubular wells and these seldom exceed seventy-five feet in depth, while the majority of those along the crest of the moraine have a depth of but forty to sixty-five feet. Consequently there is a less complete knowledge of the deeper structure of the drift than on the portion west of the Des Plaines River. The following represent the deepest wells of which sections were obtained:

At Beecher Station a well 106 feet in depth is principally in blue bowlder clay and obtains water in a gravel at the depth mentioned.

On the crest of the moraine at C. L. Pease's residence, one mile north of Goodenow, a well 112 feet in depth is in blue bowlder clay to the water-bearing gravel at bottom.

J. O. Piepenbrink, Section 11, Crete Township, has a well 106 feet in depth, which has the following section:

1. Yellow, pebbly clay, of reddish cast	20 feet
2. Grayish-blue, pebbly clay	85 "
3. Coarse sand	1 "
Depth	106 feet

Mr. Piepenbrink finds the blue clay less pebbly than the yellow clay and the blue clay varies greatly in hardness in different wells on his farm and also varies at different depths in the same well.

In the village of Crete nearly all the wells enter sand at slight depth, and cellars are frequently drained by boring a few feet in their bottoms to a dry sand, which absorbs their water. The

following section of a well in Sec. 8, Crete Township, is representative:

1.	Yellow, pebbly clay	15 feet
2.	Blue, pebbly clay	8 "
3.	Dry sand	12 "
4.	Quicksand and water	17 "
	Depth	52 feet

In some wells the sand lies within ten feet of the surface and has no blue clay above it.

The following sections of well borings near Spencer will illustrate the structure and show the general thickness of drift in that locality:

Section of well at elevator in Spencer—

1.	Yellow, pebbly clay	12 to 15 feet
2.	Blue, pebbly clay, hard and dry	50 "
3.	Cemented sand	3 to 4 "
4.	Quicksand	5 to 6 "
5.	Limestone at 75 feet (1)	

Section of well two miles south of Spencer—

1.	Yellow, pebbly clay	8 feet
2.	Sand and gravel	14 "
3.	Blue, pebbly clay, hard and dry	60 "
4.	Limestone at 82 feet	

Carbonic acid gas has been encountered quite frequently in wells along this moraine. It is usually found in dry cavities in the blue clay and is struck at various depths.

In the outlying belt in Will County, from the Des Plaines River southeastward, the thickness of the drift is much less than in the main belt, being as a rule between forty and seventy-five feet. There is usually at surface ten to twenty feet of yellow till. Beneath this is occasionally found a bed of sand or gravel of slight depth, but usually blue till immediately underlies the yellow. In the blue till beds of blue quicksand are often struck. These beds are, in this district, sometimes ten feet or more in depth, and offer great obstruction to well-digging or boring. Such quicksand is not uncommon in other districts in Northeastern Illinois. Wells are seldom obtained in it, though it is full of

[1] It is thought that rock was struck at the bottom of the well.

water, for the reason that the sand clogs the strainer of the pump. It is also difficult to case or wall a bored or dug well in this material, it being necessary to sink the wall or casing to the bottom of the sand. Many wells are carried through this sand and a few feet of the underlying blue clay to a gravel bed or in some instances into underlying limestone.

FLOWING WELLS (1).

Palatine Flowing Well District.—In the vicinity of Palatine, in northern Cook County, there is a small district having a radius of about two miles from the village of Palatine as a center, where flowing wells are obtained. In 1887 there were eight of these wells in the village of Palatine, and at least twenty-five in the township. The writer has obtained no later information concerning this district. The depth of the wells ranges from 70 to 170 feet, the majority of them being from 125 to 170 feet in depth. Occasionally a well has struck two or more veins from which water will flow, though usually there is but one vein. The water rises in the village of Palatine from the three strongest wells about ten feet above the level of the track at the depot. These wells do not obtain water from exactly the same depth, but are among the deepest wells in the village. The head is lower in the shallow wells, water rising in some cases only about five feet above the level of the railway station. It was not determined to what height water rises in wells outside the village compared with those in the village, since they are scattered widely and no levelings have been made between the wells. The rate of discharge varies greatly even in the village of Palatine. The strongest well, which is at the cheese factory, has a discharge of sixty gallons per minute. The other wells in the village flow but one to six gallons per minute, and the wells at the farm houses outside the village seldom flow more than five gallons per minute. The water is slightly chalybeate in every well which was examined. The waters vary greatly in hardness in the different wells. All the water, however, is so hard that it is necessary to "break" it before using it for laundry purposes.

There are many deep wells in the vicinity of Palatine which do not flow, even when the surface level is lower than that at the flowing wells. The water supply is apparently from veins whose collecting areas vary in altitude, otherwise the water level would be more uniform.

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[1] These flowing wells were first discussed by me in the 17th Annual Report of the U. S. Geological Survey.

The collecting area is thought to be in the portion of the moraine west and north of Palatine. The moraine west of Palatine attains an altitude of 100 to 120 feet above the station, and the crest in Lake County has nearly as great an altitude. The superficial drainage is very poor north of Palatine, on the divide between Salt Creek and Buffalo Creek, and it is also poor west of Palatine, for there is no stream nearer than Fox River to receive its waters. Consequently much of the water must evaporate or find outlet by underground passages. There seems to be a sufficient collecting area and also a sufficient variation in altitude to account for the wells and the difference in head.

Salt Creek Flowing Well District.—South of Palatine Township, along Salt Creek and its tributaries, flowing wells are frequently obtained. They differ but little from springs which occur along the creek. There are at least six such wells along a tributary of Salt Creek in the eastern part of Schaumberg Township (T. 41, R. 10 E.), none of which exceed forty-five feet in depth. Those along Salt Creek, from Plum Grove, in southern Palatine Township, to the vicinity of Elmhurst, in York Township, seldom exceed thirty feet in depth.

In Itasca there are a few flowing wells along a tributary of Salt Creek. Of these the deepest one recorded is but twenty-eight feet. The water here will rise not more than three feet above the bed of the creek. This level is sixty-five to seventy feet lower than the level of the flowing wells in Palatine.

OUTER BORDER PHENOMENA.

While the ice sheet was forming the Valparaiso moraine there were streams of water issuing from its outer border and escaping down the Des Plaines River. These streams became overburdened with material derived from the ice and in consequence built up their beds and valley bottoms to a marked degree. The filling reached such a stage that the streams were in some cases forced to find outlet across the present interfluvial tract. Valleys were formed by these streams which are now abandoned or occupied by insignificant brooks (1).

From the contour maps prepared by the United States Geological Survey it is possible to ascertain the height to which the filling extended along the lower part of the Du Page and the Des Plaines and the elevation of these abandoned channels. From

[1] Perhaps the valleys here referred to were partially opened by subglacial streams at the time when the moraine which they cross was occupied by the ice sheet.

the Joliet sheet, which includes sections of the Des Plaines and lower Du Page Rivers, immediately outside the Valparaiso moraine, it appears that on the immediate border of the moraine the gravel filling reached an altitude approximately 620 feet A. T. These gravel deposits are extensive along the Du Page River below the junction of the West and East Forks and along the Des Plaines River below Romeo. Tracing these deposits southward, there is a marked descent, the altitude at Plainfield being scarcely 610 feet, at Grinton 590 feet, at Joliet Mound 580 feet and at Channahon 570 feet, a fall of fifty feet in a distance of about twenty miles.

The abandoned valleys which connect the Des Plaines and Du Page Rivers are not of the same elevation. The northermost one, occupied by small streams which drain it in opposite directions, each of which is known as Isle la Cache Creek, leaves the Des Plaines opposite Romeo and passes nearly directly westward to the Du Page Valley just above Plainfield. It has an elevation between 600 and 610 feet A. T. It opens out toward the southwest into an extensive gravel plain near Plainfield, having the same elevation as the channel, which was probably built up in part by the current which formed this valley. The valley is about one-half mile in width and is cut to a level forty to fifty feet below the bordering uplands.

A second valley leaves the Des Plaines about two miles south from the Isle la Cache and leads southwestward to the Du Page, entering that valley below Plainfield. Its elevation is 620 feet, or about the elevation of the gravel deposits bordering that portion of the Des Plaines Valley and somewhat higher than the deposits on the Du Page. It is not so large as the Isle la Cache and probably was earlier abandoned.

A third valley leaves the Des Plaines about midway between Lockport and Joliet and passes westward into the Du Page Valley just above Grinton. The elevation of its channel is 570 to 580 feet or ten to twenty feet below the level of the bordering gravel deposit. It is about fifty feet in depth and nearly one-half mile in width. The contours of its bluffs indicate the line of a vigorous stream. This valley was apparently the last of the three to be abandoned.

The deposits along the Du Page and Des Plaines Rivers consist in the main of coarse gravel and cobble, much of the finer material having been swept away by the strong current. Excellent exposures are to be seen in the gravel pits near Plainfield on the

Du Page and in numerous small gravel pits along the border of the Des Plaines, both above and below Joliet. One of the largest on the Des Plaines is found in an island-like remnant of the old terrace known as "Joliet Mound," about two miles below the city of Joliet, on the west side of the river. At the southeast end of this mound the following section is exposed:

1. Surface coating of silty clay	1 to 4	feet
2. Coarse gravel and cobble	10 to 12	"
3. Sandy gravel of medium coarseness, cemented in places	25 to 30	"
4. Fine sand or loam	4	"
5. Blue, pebbleless clay, laminated, calcareous	8 to 10	"
6. Bowlder bed, containing clay balls and a sandy, clay matrix, extending to river level on east side of mound, but underlain at slight depth by limestone at west side	5 to 20	"

It is thought that the bowlder belt is a result of interglacial erosion of a till sheet. The blue pebbleless clay which overlies it is apparently a still water deposit formed perhaps before the ice sheet had reached such a stage of melting as to produce vigorous drainage. The upper member appears to indicate a deposit by a stream whose vigor was greatest toward the close of deposition, for at the top the cobble is swept almost free from sand. The change, however, may have been brought about by a shifting of the main current of the stream, the coarse material being deposited over portions of the bed which had before been outside the main current.

The deposits of gravel along this valley terminate very abruptly at the south, near Channahon, there being only a fine sand on the plain in the Morris basin at the head of the Illinois. This feature is apparently due to the presence of a body of still water in the low country about the head of the Illinois River. The region is covered by sandy deposits up to a level about 575 feet A. T., on the border of which there are in places well defined beach lines. This lake had a western outlet through the Marseilles moraine down the Illinois. Its beaches are traceable a short distance beyond Morris. Further west the body of water became narrowed to the width of the Illinois valley and changed to an eroding agent.

It is probable that each of the small tributaries of the Kankakee, which head in the Valparaiso moraine, and also eastern tributaries of the Des Plaines, were lines for escape of glacial waters, but the writer has not examined the valleys to determine the effect of such

waters, excepting the valley of Hickory Creek, which enters the Des Plaines at Joliet. This valley has a moraine-headed terrace, setting in at the outer border of the moraine in Sec. 17, New Lenox Township. It has a gently undulating surface for a mile or more out from the border of the moraine; its surface then becomes plain. This gravel plain is nearly as high as the bordering till plains 620 to 630 feet A. T. and 60 to 70 feet above the present stream.

On the east side of the West Du Page River, from Naperville northward, the gravelly deposits of the moraine graduate into terraces or gravelly aprons, which lead down the valley. The low gravelly knolls of the moraine disappear in a nearly plane surfaced apron on descending to the border of the river. This gravel apron is not so extensive as the deposits of the lower Du Page, above described, and is now seen only as remnants along the valley border.

The East Du Page throughout its entire length drains a broad slough, which separates morainic ridges. Its bottom is said to be underlain by deposits of gravel and cobble.

LAKE BORDER MORAINIC SYSTEM.

THE MORAINES.

Between the Valparaiso moraine and the shore of Lake Michigan there are, in Cook and Lake Counties, a series of nearly parallel till ridges. We can perhaps best describe them as the West Ridge, Middle Ridge and East Ridge. Though usually distinct, the ridges are in places coalesced as described below.

The Outer or West Ridge.—The outer or west ridge enters Illinois from Wisconsin on the west side of the Des Plaines River, its outer border being for a few miles followed by Mill Creek, while its inner extends to the west bluff of the Des Plaines River. Just below Gurnee the river passes through the moraine and for several miles south follows closely the outer border. The river then bears away from the ridge a short distance and the outer border of the ridge for the remainder of its course lies a mile or more east of the stream. In Lake County the ridge is sufficiently prominent and bulky to constitute a marked feature and has a general width of about two miles. In the south part of the county it sends out a spur to join the middle moraine belt near Deerfield, while the main ridge continues south into Cook County, gradually decreasing in strength and dying out in a plain near Mont Clare, in the southwestern part of Jefferson Township (T. 40, R. 12 E.). For five or six miles north from its southern terminus it rises scarcely ten feet above the bordering plains, and is distinguishable from them mainly in being more undulatory. Where well developed, as in northern Lake County, the moraine has numerous knolls, 20 to 25 feet in height, and these stand upon a basement ridge whose relief is nearly twenty-five feet. A noticeable feature of this and also of the other ridges of this system is the difference in the breadth of the outer and inner slopes, the usual breadth of the outer slope being scarcely one half that of the inner.

The Middle Ridge.—As already noted, this ridge is joined to a spur from the west ridge, south from Deerfield. The combined belt finds its southern terminus near the head of the Chicago River and at the border of the old lake. A possible continuation southward is discussed below. The course of the belt is south to north, through Northfield Township, Cook County. Upon entering Lake County it becomes distinct from the spur and remains

a distinct ridge for a distance of fifteen miles. It there, in Sec. 18, Waukegan Township (T. 46, R. 12 E.), becomes united with the east ridge and remains so as far north as it has been examined. On each side of this ridge there is a narrow sag or slough. The sag on the east is marshy its entire length from Winnetka, in Cook County, northward to the latitude of Waukegan, a distance of nearly twenty miles. For a couple of miles at its southern end it has a width of one-half mile or more, but the usual width is only one-fourth mile. The sag on the western, or outer, border contains a marsh from Rondout station south to the Lake and Cook County line, a distance of about nine miles.

This ridge, like the west ridge, has low knolls along its crest, 8 to 15 feet in height, but the coalesced ridge in Northern Cook County is more billowy and carries knolls twenty feet or more in height. There are basins and winding sloughs among the knolls, which add to the expression of the moraine.

The East Ridge.—The southern terminus of the east ridge is at Winnetka, where the present lake cuts it off. It has apparently had its entire east slope and a portion of the crest removed by the lake, there being a descent immediately from the bluff on the lake to the slough, which lies west of the ridge. Following the ridge north to Highland Park the crest and east slope appear. Continuing north to Lake Forest, a narrow till plain appears on the east of the ridge, the inner border of the ridge lying back a half mile or more from the lake front. Still farther north at Waukegan, the inner border lies back about two miles from the lake front. The usual width of this ridge, where complete, is about one mile. The crest of the ridge usually stands 110 to 125 feet above the lake. At Winnetka, the higher portion being removed, it rises but 80 feet above the lake. The till plain east of the ridge stands 75 to 90 feet above the lake.

The rate at which the lake bluff is being encroached upon by wave action has become a matter of much concern to the residents. It is estimated by old settlers that from Waukegan to Evanston there has been, during the thirty years from 1860 to 1890, a strip about 150 feet in width, undermined and carried into the lake. This amounts to about 500 acres, representing at present valuation nearly one million dollars' worth of property.

Relief.—The west ridge rises with a somewhat abrupt slope about twenty-five feet above the plain along the Des Plaines River. On the inner (eastern) side there is a gradual descent of

about forty feet to the plain along the Chicago River, and of 20 to 25 feet to the marshy plain in Lake County.

The middle ridge has a relief of 20 to 25 feet above the marshy plain on its outer border, and a gradual slope of 25 to 40 feet to the sag or slough, which lies on its inner border.

The east ridge has a relief of 20 feet in Northern Lake County and 35 to 40 feet in Southern Lake and Northern Cook Counties above the sag on its outer border. The reliefs of all these ridges are lessened at the northern end because of increase of elevation in the sags or plains which separate them. The ridges each maintain a nearly uniform height above Lake Michigan throughout their course in Illinois.

Thickness of Drift.—In numerous borings, 75 to 100 feet in depth, no rock is struck and no outcrops of rock occur along this portion of the lake shore. The drift beneath the level of the base of these moraines is probably largely of earlier date. The following list of borings which have struck rock indicates that in several places at least the rock surface lies much below the surface of Lake Michigan.

1. At Senator C. B. Farwell's artesian well, in Lake Forest, rock is struck at 160 feet. The well mouth is 40 to 45 feet below the crest of the east ridge at Lake Forest and about 75 feet above Lake Michigan.

2. At Highland Park rock is struck at 160 to 175 feet. The elevation above the lake is 100 to 115 feet.

3. At Lloyd's artesian well, in the north part of Winnetka, rock is struck at 150 feet. The well mouth is by surveyors' level 78 feet above Lake Michigan.

4. At Ravinia a well strikes rock at 164 feet. The surface level has not been accurately determined, but it is probably about 100 feet above Lake Michigan.

5. Near Schermerville rock is struck at 147 feet. The surface elevation does not exceed 100 feet above Lake Michigan.

6. On the crest of the west ridge in Sec. 14, Maine Township (T. 41, R. 12 E.), rock is struck at 110 feet. The elevation is probably about the same amount above the lake.

Structure of the Drift.—Along the lake shore the bluffs from Winnetka to the vicinity of Waukegan rise abruptly 75 to 90 feet and present many good exposures of the drift to this depth. There is at the surface a pebbly yellow clay 8 to 13 feet in depth, which is similar to that in the Valparaiso moraine. Beneath this clay is a grayish blue till containing occasional sand pockets saturated with

water. These, however, form but a small part of the drift. The bulk of the bluff is a compact till, but moderately pebbly and exposing only an occasional imbedded bowlder. It was noted that the pebbles and bowlders are usually glaciated.

Neither the east ridge nor west ridge nor the northern portion of the middle ridge has gravel knolls of any consequence, but the southern portion of the middle ridge lying in Cook County has many such knolls. Indeed, nearly every prominent knoll contains gravel. It seldom exceeds 15 feet in depth and appears to be confined to the knolls, for they are situated on a basement ridge of till similar to the till exposed along the lake bluff. But one complete reliable section of the drift could be obtained, which, though valuable, needs to be supplemented by other records to furnish a satisfactory knowledge of the lower portion of the drift. The well is located at Ravinia. Its section was furnished by William McWendle, of Oak Glen.

1. Pebbly, yellow clay	11	feet
2. Grayish-blue, pebbly clay	60	"
3. Gray clay, very pebbly	10 to 12	"
4. Grayish-blue, pebbly clay, lighter color than No. 2	70	"
5. Clay, resembling putty	4 to 5	"
6. Limestone	22	"
Total drift	164	feet

SUPPOSED CORRELATIONS.

None of these moraines have been found to have connection at their southern end with the massive Valparaiso moraine, nor do they admit of continuous tracing around the southern end of the lake within (north of) that moraine. The weak development in that district seems the more remarkable since there is on the east side of Lake Michigan, northward from Porter County, Indiana, a series of ridges of similar size and complexity to that under discussion and which are probably its continuation. The conditions which affected the southern end of the ice lobe at the time these belts were forming are so poorly known that it may be difficult to ascertain what caused this wide gap. The question naturally arises whether the expanded lake and its old outlet may not have removed the ridges.

In the case of the western ridge this suggestion is inapplicable, since the terminus at Mont Clare is outside the well-defined beaches and above their level. The ice sheet here, however, may

have terminated in water held between its front and the Valparaiso moraine in the brief period required for the cutting down of the outlet to the level of the upper beach. But in that case, while wave action may have removed weak morainic features, it seems scarcely probable that there could have been a complete obliteration of so strong a belt as is present in districts to the north. In the case of the Middle and East Ridges, as shown below, there may have been some erosion by the lake outlet and lake waves.

The Blue Island Ridge.—The Middle Ridge has its southern terminus as a well-defined ridge at the point where it meets the Upper beach. There is, however, near the southwestern limit of the city of Chicago a till ridge, and connected with it a bowlder belt, which may be correlatives of this morainic ridge.

The till ridge referred to is known as "Blue Island." It leads north to south for a distance of about six miles, along the line of Calumet and Worth Townships. Blue Island village is situated at its southern end. At that end the ridge stands about 60 feet above Lake Michigan, but rises northward to an altitude 85 to 90 feet above the lake. Its width, including the slopes, is only about one mile. The northern portion is gently undulating and is strewn with bowlders, but the remainder of the ridge is smooth and comparatively free from surface bowlders. Around this ridge there are shore marks in the form of eroded banks or terraces and gravelly beaches at an altitude 55 to 60 feet above the present lake level. On its west border sand from the old lake shore is drifted into dunes that extend nearly to the top of the ridge. Blue Island ridge owes its elevation to a thickening of the drift deposits, for the rock surface is as low beneath it as on border plains. A well at Morgan Park, near the crest, reaches a level 70 feet below the base of the ridge before entering limestone.

Bowlder Train.—A train of bowlders is traceable north from the north end of Blue Island through the western part of the city of Chicago to the vicinity of the Chicago River in Jefferson Township. Although portions of the line fall within a thickly settled portion of the city, the bowlders still remain in sufficient numbers to be a noticeable feature. In the thinly settled district from South Lynne southward to Blue Island they remain in about their natural abundance. The belt occupied by the bowlders is a mile or more in width. There appear to have been several hundred bowlders to the square mile along this line, while on bordering districts there are estimated to have been less than 100 to the square mile. From the north end of this bowldery tract to the south end of the

Middle Ridge the interval is but a few miles and is mainly covered by heavy deposits of lake sand and gravel which would obscure any bowlder connection which may have existed. There seems, therefore, nothing to oppose the correlation of the bowlder train and Blue Island ridge with the Middle ridge.

From the south end of Blue Island ridge to the till ridges in Porter County, Indiana, no line of bowlders or indication of the position of the ice margin has been found. Such features may however, be concealed in much of that district by the heavy deposits of lake sand.

Continuation of East Ridge.—The East ridge apparently had some continuation southward beneath the present lake. Prof. L. E. Cooley, of the Chicago Drainage Commission, informs me that in a series of dredgings in the south end of the lake, made a few years since under his direction, a bowldery belt was traced for several miles southeastward from the terminus of the East ridge at Winnetka. This bowldery belt is perhaps a residue from a ridge of till which has been cut away by the lake.

ASSOCIATED TILL PLAINS.

The ridges just discussed occupy but a small portion of the area embraced between the Valparaiso moraine and the shore of Lake Michigan. The greater part of the area is a plain underlain by till deposits. On this plain, as is shown later, the lake has built or carved its shore lines and made thin deposits of sand or gravel.

Altitude and Slopes.—In the portion of the plain west and south from Chicago the altitude at the border of the Valparaiso moraine is 620 to 630 feet A. T., or 40 to 50 feet above the lake. From this border there is a gradual descent toward the present shore of Lake Michigan, where the altitude is about 590 feet A. T. This portion of the plain was covered by the lake at the time the upper beach was formed, the altitude of that beach being 635 to 640 feet A. T.

Upon passing northward along the till plains just described the narrow plains which separate the ridges soon rise above the level of the Upper beach. The plain that lies between the West ridge and the Valparaiso moraine slopes eastward at the rate of several feet per mile. Its west border next the Valparaiso moraine rises from 635 feet at Ovington station, on the Omaha division of the C. & N. W. railroad, to about 690 feet at the line of Cook and Lake Counties, a distance of 18 miles, and about 725 feet in northern Lake County at the line of Illinois and Wisconsin, a distance of 24 miles farther.

This rise of $1\frac{1}{2}$ to 3 feet per mile is, of course, not perceptible to the eye.

The plain between the West and Middle ridges rises from 630 feet at Oak Glen to 680 feet at Deerfield, a distance of six miles. From Deerfield north to the State line, a distance of 24 miles, it is shown by the C., M. & St. P. railway survey to stand at 670 to 685 feet A. T. Russell station, near the State line, is 673 feet.

The plain between the Middle and East ridges rises from 630 feet opposite Winnetka to about 670 feet at the point where the ridges unite, 20 miles north from Winnetka.

Thickness of Drift.—On this plain there is much difference in the thickness of the drift and since the surface, aside from the till ridges just described, and the low beach lines, has very little variation in altitude, the difference in depth is due almost entirely to the variation in surface of the underlying rock strata. Within the city of Chicago, where the surface is especially flat, several rocky prominences come to the surface, or are concealed but slightly by drift, while among them the drift accumulations extend to depths of 100 to 125 feet or more (1).

Mr. Samuel G. Artingstall, while City Engineer, prepared a map of the city giving the distance to rock at many places. This indicates that a filled valley with rock floor 100 to 125 feet below lake level passes through the north central part of the city, entering the lake south of Lincoln Park.

West from the city the rock rises over quite extensive areas very nearly to the surface of the plain, or to a height of 30 to 60 feet above the level of Lake Michigan. On the border of the Chicago outlet there is a nearly continuous exposure of rock from near Summit to the head of the Illinois.

In the northern portion of the district, between as well as beneath the till ridges, the rock surface has an average altitude slightly lower than in the low plain in the vicinity of Chicago, for the majority of the wells go about 50 feet below the level of Lake Michigan before entering rock. It is estimated that the thickness of drift in this northern portion will average nearly 150 feet, while in the low plain the average will scarcely exceed 50 feet.

Structure of Drift.—The drift beneath this plain, like that of the moraine, consists largely of a soft blue till beneath which are remnants of a hard till of earlier age. The tills appear to be of

[1] A large amount of material has been collected by the Geological and Natural History Board of The Chicago Academy of Sciences, with a view to preparing a topographic map of the rock surface underlying the city and border tracts, and which is designed to be published as a bulletin of the Academy.

Fig. 1. Exposure near Willow Springs, made by Chicago Drainage Canal, showing large bowlders below a bed of peat. The outcrop of peat may be seen in the edge of the bank back of the bowlders. (Photograph by the Chicago Drainage Commission.)

direct glacial deposition even in portions of the plain which lie within the limits of the beaches. The clayey matrix of the soft till is scarcely so thickly set with stones as that of the underlying hard till. In both tills many of the stones are glaciated. The rocky constituents grade from bowlders two to three feet or more in diameter down to minute pebbles. These in the upper or later till are made up in large part from the local Upper Silurian rocks, probably less than 10 per cent. being from the pre-Cambrian Canadian rocks. Devonian rocks from ledges to the north of Chicago are sparingly represented. The clayey matrix is highly calcareous and under the microscope it is found that angular or but slightly rounded grains of limestone constitute a large proportion of the fine material. With the minute limestone fragments, there appear quartz grains, bits of shale and fragments from crystalline rocks of various kinds. Whether the rock constituents of the lower till differ markedly from the upper has not been ascertained. Its situation immediately upon the Niagara limestone would in all probability result in the incorporation of an even larger proportion of this rock than appears in the upper till.

One of the most conspicuous instances of the occurrence of the lower till within the Chicago area is that brought to light in the excavation of the Chicago Drainage Canal. Immediately east from Summit the canal for a mile or so extends a few feet into a very hard, partially cemented till apparently of early glacial age. Its hardness compared with that of the overlying till is so marked that the contractors who engaged to excavate this part of the channel were obliged to abandon the steam shovel which had been used in the soft till and resort to blasting. It is probable that this old drift fills depressions in the rock quite extensively in this district, but as no special attention has been given its identification the instances recorded are not numerous. The well drillers usually recognize the hard till and apply to it the term hardpan, while the soft till is called clay.

Although the great body of the drift is till, there are found numerous thin beds of sand or gravel in which water collects in sufficient quantity to supply the wells. There are also small pockets of dry sand or gravel occupying but a few cubic feet each. Such pockets were found in the excavation of the main lake tunnel for water supply. They were in some cases completely inclosed by till.

On the surface of the plain both above and below the level of the upper beach there is quite generally present a clay, varying

in thickness from a few inches up to several feet, in which pebbles are far less numerous than in the till. It however carries occasional bowlders. This deposit seems attributable to the combined agency of water and ice. It was probably a deposit made in a body of water held between the ice front and the Valparaiso moraine while the ice sheet was still in the immediate neighborhood of the moraine.

In the district within the limits of the upper beach there are deposits of sand and gravel marking the shore lines of the lake. These deposits form a less regular coating than the clay just mentioned. Over much of the plain the deposition was so light as to leave scarcely a trace of sand in the soil, but in places the deposits cover the till of the old lake bottom to a depth of 20 to 25 feet. The heavy deposits are found chiefly along the present lake border from Evanston southward, where there is a continuous belt of sand ranging in width from one-half mile to three or four miles, and having an average depth of not less than 10 feet. The southwestward lake outlet appears to have carried away much of the sand which was brought into the southern end of the lake while that outlet was open.

The depth of leaching and oxidation is markedly less on the plain covered by the lake than on the till ridges or the Valparaiso moraine. Numerous tests with hydrochloric acid show the leaching on the plain to extend only to a depth of a few inches, seldom more than two feet, while on the ridges it is rare to obtain a response at less than five or six feet from the surface. On the plain the surface oxidation of the till is only two to six feet, while on the ridge it is six to ten feet or more. This difference in the amount of oxidation and leaching is probably attributable in part to the flatness of the plain and in part to the later date at which the plain was exposed to atmospheric action.

There have been several deep lines of excavation made in Chicago and vicinity which have afforded excellent oportunities for studying the structure of the drift. The longest line is the drainage canal, now under construction, which opens a channel 25 to 40 feet in depth from the Chicago River at Bridgeport to the Des Plaines River at Summit, that is entirely in drift. Along the Des Plaines also the excavation is largely in drift to the vicinity of Lemont, where the canal becomes a rock channel. From Bridgeport to Summit there is little besides till, but from Summit to Lemont gravel, sand and the coarser material deposited along

Fig. 2. Exposure showing variability in coarseness and in dip of beds in the Chicago outlet near Willow Springs. [Photograph by the Chicago Drainage Commission.]

the line of the old outlet form a large part of the section. (See Figs. 1 and 2.)

In the Fullerton avenue conduit which leads eastward into the lake through the north part of Chicago the drift is mainly till, but the surface sand is a conspicuous deposit. From its western end to within 2,000 feet of the lake the rock surface is found at a depth of 43 to 54 feet. Within 100 feet east from this point it drops down to 80 feet, passes below the conduit, and does not appear further east. The sand has its greatest thickness at about 1,700 feet from the lake, where it reaches 25 feet. It decreases westward to 17 feet at 2,100 feet from the lake, and to 12 feet at 6,000 feet, and entirely disappears before reaching the Chicago River valley. Toward the lake shore also it decreases, being about 18 feet in depth for 1,400 feet west from the shore. At the water's edge the depth is but 10 feet. The profile continues out 1,100 feet below the lake, and there is but three feet of sand at its terminus.

The profile of the lake tunnel shows the rock to be at a depth of 37 feet at the working shaft four miles inland. Eastward from here the distance to rock gradually increases to a point about two and four-tenths miles from the lake shore, being between 50 and 60 feet at that point. It there drops down rapidly to a level nearly 90 feet below the surface, and is not encountered farther east. For two miles out beneath the lake the excavation reaches 60 feet or more below the lake bottom. The tunnel was through till its entire length. It shows, as noted above, pockets of sand inclosed in the till. The surface sand, as in the Fullerton avenue conduit, is of considerable depth.

In Hyde Park Township in the south part of Chicago numerous borings and excavations show the sand deposits to be from five feet up to about 20 feet in depth. Except where the rock comes near the surface till is found to underly the sand.

STRIAE.

Exposures of striae are numerous and indicate that the axial movement of the ice sheet in this district was decidedly west of south rather than due south. This should be borne in mind in estimating the amount of divergence in the lateral flowage. The striae in this region are remarkably well preserved, and that, too, where conditions for obliteration seem favorable. In some places there appears to have been no drift protecting the ledges since the withdrawal of the lake, if not since the time when the ice sheet withdrew, and yet but few exposures do not preserve the striae. In similarly exposed situations outside the Valparaiso moraine striae are seldom preserved. This difference may be due partly to the greater age of the striae outside the moraine. But aside from this there appears to have been an original difference in the intensity of glaciation by which ledges more often escaped the rasping action of the ice sheet outside the moraine than in the district between the moraine and the lake.

The following embrace the localities where bearings were observed:

1. Stony Island in south part of Chicago. The rock where glaciation was observed dips toward the southeast, with an angle of nearly 40 degrees, and heavy scorings follow the line of strike, with a bearing S. 44 degrees W. (See Fig. 5.) Associated with these are striae of feebler development, which vary in direction fully 10 degrees to the east and west of the heavy scorings, thus ranging from S. 34 degrees to S. 54 degrees W. An escarpment of the dipping layers rising about six feet above the remainder of the quarry is glaciated not only on the upper surface and nearly vertical front, but also beneath one of the lower layers, its dipping under surface being smoothly polished for about 18 inches back from the front of the ledge. (See Fig. 4, where the glaciated under surface appears near the sachel.)

2. On Thorn Creek near Thornton. The prominent portions of arching layers of the Niagara limestone are roche moutonneed and a few striae have a bearing S. 31 degrees W.

3. Quarries one mile southwest of Blue Island. A few faint striae were observed bearing S. 54 degrees W.

Fig. 3. Long range view of an outcrop on "Stony Island," in Chicago, which has been striated on face and under surface as well as on top. [Photograph by Gayton A. Douglass, March, 1897.]

4. On west side of Des Plaines River, one-fourth mile north of Santa Fe Railway bridge. An area of several square rods of limestone surface is heavily glaciated. Grooves one-half inch in width are common and there are a few fully two inches in width. Fine lines are numerous. The bearing corrected for magnetic variation is very nearly due west, the magnetic bearing being 3 to 4 degrees south of west. This striated surface slopes perceptibly toward the southeast, there being a descent of 2 to 3 feet in as many rods. The glaciation was therefore made on an ascending surface.

5. Immediately west of Summit on the west side of the Des Plaines. The striae here observed are faint lines bearing S. 38 degrees W.

6. Between Willow Springs and Sag bridge, in the bed of the Drainage Canal. The striae here observed consist of faint lines bearing S. 23 degrees W. They appear over a space of several square yards. (See Fig. 6.)

7. At Lemont, about 500 feet from the Santa Fe Railway bridge. Mr. Ossian Guthrie reports that heavy grooves have a bearing about S. 60 degrees W. They were exposed in the excavation for the diversion channel for the Des Plaines. A view of these grooves is given in Fig. 7, but the present writer thinks they may be the product of the waters of the Chicago outlet rather than glacial striae.

8. Lyons, quarry in south part of village. Nearly all the striae bear S. 70 degrees to 75 degrees W., but scattering striae range from S. 44 degrees to S. 71 degrees 30 minutes W.

9. La Grange quarry. Scattering striae on a planed surface. Bearing S. 58 degrees 30 minutes W.

10. Hawthorne quarry. There are here two sets, each quite heavy scorings. The earlier set follow approximately the line of strike of the dipping layers, bearing S. 64 degrees to 68 degrees W. The later set cross the upturned edges of the layers at a small angle, bearing S. 52 degrees to 54 degrees W.

11. Quarry at crossing of Chicago avenue and Western avenue, Chicago. A few faint striae preserved have a bearing S. 72 degrees W.

12. Excavation for Fullerton avenue conduit in north part of Chicago. Bearing S. 60 degrees W. (recorded in profile of conduit).

13. On Eighteenth and Robey streets, Chicago. The surface of arching layers is *roche moutonneed*. The prominent portions of the surface are striated, the bearing of the striae ranging from S. 52 degrees to S. 57 degrees W.

14. Covel's quarry near Elmhurst, Sec. 17, Tp. 39, R. 12 E. The surface is planed quite extensively and covered with a multitude of striae, bearing S. 63 degrees W.

15. Joliet, bearing 20 degrees north of west. An exposure of striae with this remarkable bearing was found on ledges in the Des Plaines valley, a short distance southeast of the State Penitentiary. The ledges stand 10 to 20 feet above the valley bottom and several striated surfaces were found, with small grooves, as well as fine striae.

16. Du Page bluff, near C., R. I. & P. Railway bridge, east of Minooka. Prof. J. A. Udden reports an observation of heavy glaciation, with grooves bearing about southwest.

17. Near Wilton, quarries are opened, which expose surfaces heavily glaciated with grooves bearing about S. 40 degrees W.

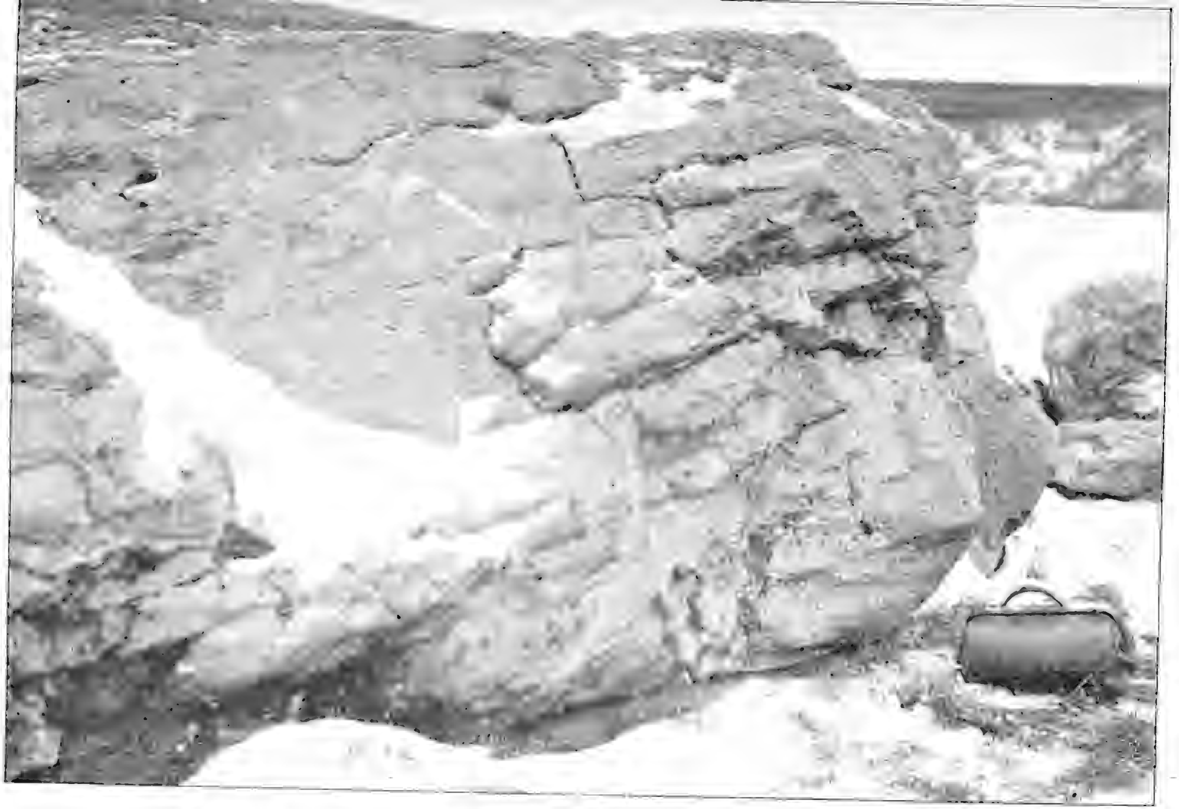

Fig. 4. Near view of preceding. The striation on the under surface may be seen near the point where the hand satchel stands. [Photograph by Gayton A. Douglass, March, 1897.

THE CHICAGO OUTLET AND BEACHES OF LAKE CHICAGO.

PREVIOUS WRITERS.

It is perhaps impossible to determine who was the first person to recognize the evidence or form the conception of a southwestward outlet from Lake Michigan to the Des Plaines. Inquiry among the old residents of this region shows that many of them recognized the beaches as products of the lake, and they also noted that the lake once discharged into the Des Plaines Valley. Evidently these conceptions were entertained for many years before any notice appeared in scientific publications.

Bannister.— Probably the earliest scientific account of the outlet is that given by Dr. H. M. Bannister in the Geology of Cook County, published in 1868, as a part of the Geology of Illinois. However, a report upon the survey of the Illinois River, by Col. James H. Wilson and William Gooding, was published the same year in the report of the U. S. Army Engineers, which makes reference to the former southwestward discharge of Lake Michigan. Dr. Bannister opens his discussion of the old lake outlet and the raised beaches with the following statement:

"It is evident with a very little observation that at a comparatively recent period, subsequent to the Glacial epoch, a considerable portion of Cook County was under the waters of Lake Michigan, which at that time found an outlet into the Mississippi Valley through the present channel of the Des Plaines."

Dr. Bannister apparently makes no claim to discovery, as is natural, in view of the fact that the outlet had been recognized as such by residents for many years.

Andrews. — One of the early publications of this Academy presents a discussion of the beaches prepared by Dr. Edmund Andrews, a publication which has attracted wide notice (1.) This paper, however, deals mainly with the work of the lake at its present stage. The ancient beaches are briefly discussed, but the outlet is not described. A map accompanying the paper shows the extent of the old lake beyond its present limit from the southern end northward some distance into Wisconsin and Michigan.

[1] The North American Lakes Considered as Chronometers of Postglacial Time, by Dr. Edmund Andrews, Trans. of Chicago Academy of Sciences. Vol II, 1870. Article 1, pp. 1-24.

Chamberlin. — Prof. T. C. Chamberlin has presented a brief discussion of the beaches along the Wisconsin shore of Lake Michigan in the Geology of Wisconsin (1), which includes many important data concerning the shore phenomena and an interpretation of the lake history. In the twenty years which have elapsed since this report was published, the studies of the shores of the Great Lakes have brought out a more complex history than had been anticipated, hence the interpretation does not fully meet the case, though it recognizes important fluctuations of lake level.

Leverett. — Although there have been frequent references to the southwestward outlet and the ancient beaches, in geological literature, within the past 20 years, no publication especially devoted to them appeared until 1888, when a paper was published by the present writer in the Transactions of the Wisconsin Academy of Sciences, entitled "Raised Beaches at the Head of Lake Michigan" (2). This paper gives a somewhat detailed account of each of the several beaches found south of latitude 42 degrees 30 minutes, the latitude of the line of Wisconsin and Illinois. It contains but a brief reference to the outlet.

Cooley.—Prof. L. E. Cooley, consulting engineer of the Chicago Drainage Commission, has published two papers which deal to some extent with the Chicago outlet (3). The first paper discusses the outlet as a means for improving the sanitary conditions at Chicago. The second paper deals with it as an important line for navigation and discusses the proper means for obtaining the best results. This paper contains a large amount of valuable data concerning the regimen of the Illinois and Des Plaines Rivers.

Marshall. —The Report of the U. S. Army Engineers for 1890 contains much material collected by Capt. W. L. Marshall concerning the Chicago outlet as a channel for navigation; also references to earlier work by that organization.

Taylor.— Mr. F. B. Taylor has published, in the American Geologist, observations on high beaches in the northern portion of the basin of Lake Michigan. These beaches he thinks pass beneath the present lake level before reaching the southern end of the basin (4). This being the case they have no connection with the outlet under discussion.

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[1] Geology of Wisconsin. Vol. 2, 1877, pp. 219-233.

[2] Trans. Wis. Acad. of Sciences. Vol. VII, 1883-87, pp. 177-192. Published in 1888

[3] Water Supplies of Illinois in relation to Health. Report of State Board of Health, 1889.
Lake and Gulf Waterway. Private publication, 1890.

[4] American Geologist. Vol. XIII, May, 1894.

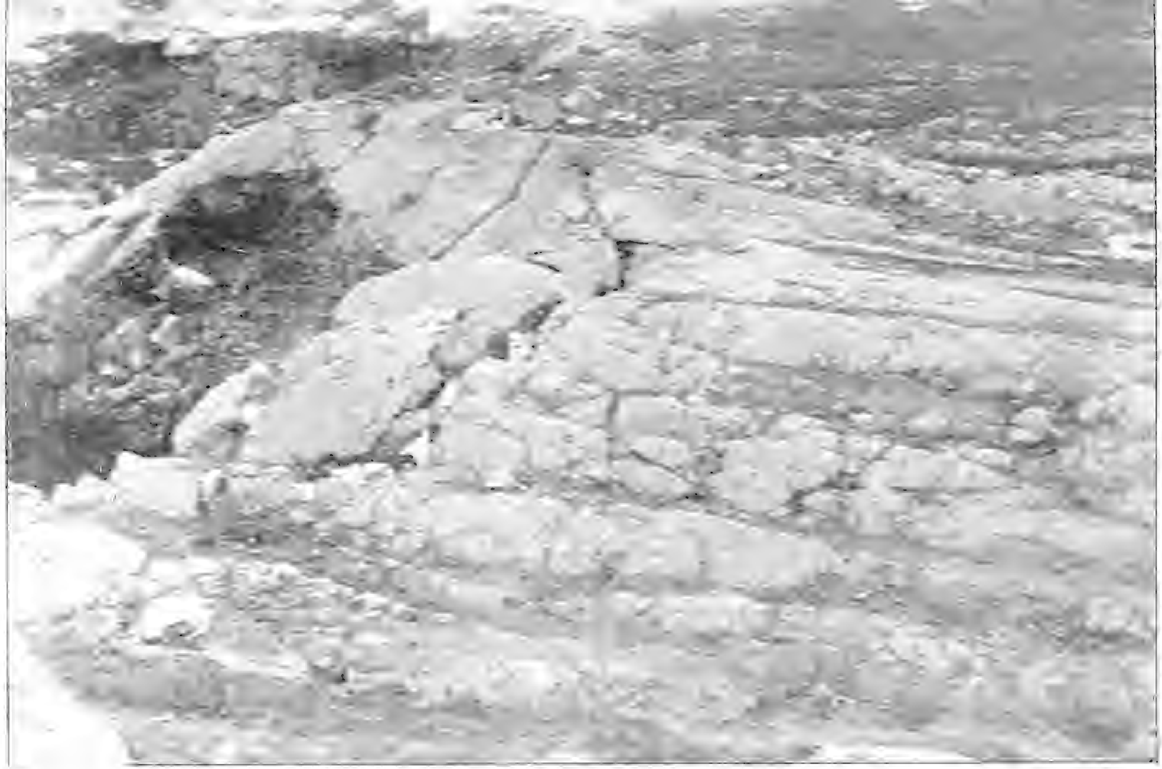

Fig. 5. View of a glaciated surface on "Stony Island," near the preceding, and at about the level of the base of the outcrop. The view looks directly across the line of ice movement. The large trough like channels are depressions between the successive layers of an inclined series of beds, and are only partly produced by glaciation. [Photograph by Gayton A. Douglass, March, 1897.]

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photographs, I am indebted to Mr. Gayton A. Douglass and to the Chicago Drainage Commission. In the preparation of maps, I am indebted to several members of the Chicago Drainage Commission; also to the Inland Educator Company for an electrotype of the map of North America.

occupied its present level. Where the shores are of drift clay the terrace generally has a breadth of from 2 to 6 miles, but at the south end of Lake Michigan it is nearly ten miles. The west shore of Lake Michigan was examined in some detail between Chicago and Manitowoc and found to have an average width of 3.98 miles. This terrace slopes gently outward to the depth of about 60 feet, when the bottom dips more suddenly to the deep water of the basin. It is thought by Dr. Andrews to be the product of wave action and is denominated by him the terrace of erosion. The present writer, however, has no opinion concerning its origin. The time required for the formation of this terrace was computed by using the average width of the terrace as a dividend and the annual rate of erosion as a divisor. As the outer edge of the terrace is at the depth of 60 feet, the position of the old shore was assumed to be at a point where a line drawn from the top of the present bluff of the lake to the outer edge of the terrace would meet the surface of the lake. These estimates give the average position of the old shore, a distance of 2.72 miles from the present shore. Dividing this distance by the annual rate makes the total age of the terrace 2,720 years, or a duration nearly the same as that computed by the drifting of the sand. If the rate of erosion determined by the Wisconsin Survey be substituted the age would be 4,708 years.

The estimate based upon the rate of erosion of the shore of the lake is probably much more reliable than that based upon the drifting of the sand past the piers, but the great variability in the height of the shore (from 10 feet up to 100 feet or more) and the variability in the rate of recession (from 0 to 16.95 feet per year) make it evident that the above computation is at best only a rude approximation. These estimates serve, however, as a provisional measurement of the duration of this stage of the lake and have much value in its bearing upon the length of postglacial time. Dr. Andrews remarks that they are useful, in showing that it is impossible to allow, even on the most liberal estimates, any such postglacial antiquity as 100,000 years, which has often been claimed.

ACKNOWLEDGEMENTS.

In the preparation of this paper and its illustrations, I am happy to acknowledge the aid kindly given by many persons, among whom should be mentioned Prof. Oliver Marcy, Prof. L. E. Cooley, Prof. W. K. Higley, and, most of all, Prof. T. C. Chamberlin, the President of this Academy. In the preparation of

North line, Sec. 21, T. 4, R. 23	15.58	14.50	1.08
West line, Sec. 22, T. 4, R. 23	19.39	18.43	0.96
North line, Sec. 27, T. 4, R. 23	26.39	26.39	0.00
North line, Sec. 34, T. 4, R. 23	16.04	15.47	0.57
West line, Sec. 34, T. 4, R. 23	31.50	30.00	1.50
North line, Sec. 4, T. 3, R. 23	28.03	26.50	1.53
North line, Sec. 9, T. 3, R. 23	18.82	18.00	0.82
North line, Sec. 16, T. 3, R. 23	27.80	20.60	6.20
North line, Sec. 21, T. 3, R. 23	21.25	18.00	3.25
North line, Sec. 28, T. 3, R. 23	32.22	31.16	1.66
West line, Sec. 28, T. 3, R. 23	30.20	23.87	6.33
North line, Sec. 32, T. 3, R. 23	34.85	32.40	2.45
South line, Sec. 32, T. 3, R. 23	46.60	44.73	1.87
Mean of eighteen places, chains			1.92

Same in feet, 126.72.

Loss per annum in feet, 3.33.

"The following measurements were made to ascertain the amount of the abrasion of the west shore of Lake Michigan, in Milwaukee County, since the Government Survey, made in 1835 and 1836:

Place.	1835. Chains.	1874. Chains.	Annual Loss. Feet.
South line, Sec. 1, T. 5, R. 22	45.61	44.50	1.9
South line, Sec. 36, T. 6, R. 22	15.90	14.40	2.6
South line, Sec. 24, T. 6, R. 22	19.29	18.70	1.0
South line, Sec. 21, T. 7, R. 22	8.72	8.42	0.5
South line, Sec. 15, T. 7, R. 22	5.37	2.82	4.3
South line, Sec. 10, T. 7, R. 22	43.35	41.64	2.9
South line, Sec. 3, T. 7, R. 22	19.34	17.36	3.33
South line, Sec. 34, T. 8, R. 22	22.00	18.69	5.61
Mean			2.77

"The loss in the other counties bordering the lake is less on the average."

In view of these measurements reported by the Wisconsin Survey, the rate for the entire shore is probably scarcely more than half that of Dr. Andrews' estimates.

Dr. Andrews calls attention to the existence of a submerged terrace, which, he thinks, furnishes a ready means for determining approximately the original position of the shore, and consequently the distance which the bluffs have receded since the water

Racine Point	16.00	"	"
Racine	6.00	"	"
Oak Creek	2.00	"	"
One mile further north	1.60	"	"
Milwaukee	6.25	"	"
Port Washington	2.30	"	"
One mile further north	1.50	"	"
Place further north	3.00	"	"
Place four miles south of Sheboygan	8.00	"	"
Sheboygan	6.25	"	"
Manitowoc	5.00	"	"

From the above table it appears that the average erosion in the portion of the shore between Milwaukee and Manitowoc is 4.33 feet per year, while between Milwaukee and Evanston it is 6.24 feet per year. The average erosion of the two sections is 5.28 feet.

A series of more careful measurements than those given in the above table appears in the Geology of Wisconsin and covers part of this section of the shore. The following is the statement furnished by Dr. Lapham to Prof. Chamberlin (1):

"Mr. S. G. Knight, of Racine, has carefully measured for the Geological Survey, from the nearest section corner or quarter post, to the bank of Lake Michigan, along all the section lines in Racine County, the results of which, compared with the Government Survey made in 1836, are given in the following table. Had these measurements been made at right angles to the shore line the result would have been a trifle less; but as some portions of the bank have been artificially protected we may assume the result as a close approximation to the actual amount of loss, during the past thirty-eight years in Racine County. These measurements will have their value many years hence."

LAKE SHORE IN RACINE COUNTY.

Section Lines.	1836. Chains.	1874. Chains.	Loss. Chains.
North line, Sec. 6, T. 4, R. 23	32.70	30.30	2.40
North line, Sec. 7, T. 4, R. 23	34.68	33.45	1.23
West line, Sec. 8, T. 4, R. 23	30.18	29.70	0.48
North line, Sec. 17, T. 4, R. 23	16.38	14.60	1.78
West line, Sec. 16, T. 4, R. 23	10.86	9.75	1.11

(1) Geology of Wisconsin, Vol. II, 1877, pp. 231-232.

sion that the effective work on the shores is due to waves and not to currents, and it is a matter of doubt if this lake has such a system of currents as are indicated by Professor Harrington's charts. The movement of the water seems to depend mainly upon the wind, but is governed to some degree by the contours of the shores. If the north winds prevail for a few days, as is often the case in the spring months, the surface water appears to have a southward movement throughout the breadth of the lake, and return currents must be at some depth. On the other hand, a prevailing south wind, such as occurs for short periods during the summer, will induce a northward movement across the entire breadth of the lake. The contours of the shore seem to favor a northward movement from direct west winds in the north half and a southward movement in the south half of the lake. As the prevailing winds are from the west these become the most protracted of the movements of surface water. Professor Cooley has found that breakwaters along the shore support this interpretation. In the southern half of the lake they are largely constructed to protect the harbors from the drift on the north side, while in the northern half they are constructed to protect them from drift coming from the south. In view of this apparently changeable course of lake movement, it seems doubtful if estimates, such as Dr. Andrews attempted, have the value that some have attached to them.

Dr. Andrews also made an estimate of the age of the lake from the annual amount of destruction of the bluffs. To determine the rate of erosion on the west coast of Lake Michigan he gathered a large number of observations, mostly derived from surveys, and after rejecting loose or vague estimates, as well as erosions brought to notice because of remarkable rapidity, he obtained the results given in the following table:

At Evanston the erosion is	16.95	feet	a year
At the Old Pier, two miles further north	4.90	"	"
One mile further north	3.08	"	"
At Winnetka	4.05	"	"
One mile further north	6.05	"	"
Lake Forest	1.65	"	"
Waukegan	0.00	"	"
Two miles further north	0.00	"	"
State line	16.50	"	"
Kenosha	12.00	"	"
Two miles further north	3.00	"	"
Three miles further north	12.00	"	"

Dr. Andrews estimates that the combined bulk of the beaches formed by Lake Chicago is nearly equal to that of the beach of the present lake, the proportion being 16 to 17. In this computation it was assumed that 656,000,000 cubic yards escaped through the Chicago outlet. This assumption is based on a comparison of the relative sizes of the beaches of Lake Chicago in a section outside the outlet and a section embracing the outlet.

Dr. Andrews attempted to estimate the length of time involved in the accumulation of the beach deposits by measuring the amount of sand carried southward past the piers at Chicago and Michigan City. The sand annually stopped by the two piers was found to be 129,000 cubic yards. If this represented the whole drift past the piers the period represented in the accumulation of the sand in all the beaches would be 26,000 years, and the duration of Lake Michigan at its present stage 13,000 years. He estimates, however, that not more than one-fourth or one-fifth of the southward drifting sand is stopped by the piers, and thus reduces the period to less than 6,000 years, with but about 3,000 years for Lake Michigan.

Dr. Andrews' estimates were based on the assumption that there is a southward flowing current on each side of the lake, carrying sand to its present head. Investigations made by the Weather Bureau in 1892 and 1893, under the direction of Prof. Mark Harrington (1) led him to the conclusion that the currents on the east shore in the southern portion of the basin are northward instead of southward. He accounts for the accumulation of sand on the north side of breakwaters along this coast by the action of the surf, in northerly storms, which is more transient than the currents proper and would affect the southern part of Lake Michigan only when the wind was northerly. This occasional phenomenon is very efficient when it occurs. He concludes that the estimates of time involved in the formation of beaches have, therefore, less value than would be the case were the accumulations due more largely to lake currents.

Considerable study of the movement of water in Lake Michigan has been made by the Chicago Drainage Commission, largely under the direction of Professor Cooley. As a result of these investigations, which involve not only a study of bottle papers, but also a thorough canvass of the opinions of lake captains and an examination of breakwaters, Mr. Cooley has reached the conclu-

(1) Currents of the Great Lakes as deduced from the movements of Bottle Papers during the seasons of 1892 and 1893, by Mark W. Harrington, Weather Bureau, Bulletin B, U. S. Department of Agriculture, 1894.

print and copies of it are difficult to obtain, the computations made by Dr. Andrews are presented below. Dr. Andrews apparently includes the beachlets referred to above in the present lake stage.

The lake is encroaching upon the district on its west border from the Wisconsin line southward to Chicago, though piers built along the shore in Chicago and for some distance northward now prevent further encroachment. Along the border of Hyde Park, in the south part of Chicago, the lake is building a beach and is tending to fill in rather than to extend the lake in that region. In Indiana the lake is filling in rather than extending its borders. In Southwestern Michigan it is eroding the prominent parts and filling in the bights, thus giving the lake a more regular outline. In this connection it may be remarked that the effect of the lake generally is to remove the prominent parts and fill the bights.

Dr. Andrews computed the bulk of the beach as follows: For 25 miles west from Michigan City it maintains an average cross section of about 6,000 square yards, and its contents are 264,000,000 cubic yards. In this division the beach is in the form of a lofty belt of sand dunes, about one-third of a mile wide, and in places 160 to 200 feet in height. In the next eight miles west this beach spreads out into a broad belt of low parallel ridges, about two miles in extreme width. This division has a cross section of about 16,000 square yards, after deducting the sand which was deposited by Lake Chicago. Its contents amount to 225,280,000 cubic yards. From the Indiana line, near Wolf Lake, to Chicago River, a distance of sixteen miles, the sand occupies a belt estimated to be seven yards thick on the shore and running out to a thin edge at the average distance of 2,500 yards inland. It, therefore, has a cross section of 8,750 square yards and contains 246,400,000 cubic yards. To this should be added the portion of the beach under water. This, taken for the entire distance from Chicago to Michigan City, is estimated to be about 1,011,890,000 cubic yards. The computation of the subaqueous belt is as follows: The sand at the shore line is about 10 feet deep, and it extends out to where the water reaches a depth of 24 to 36 feet. The breadth varies greatly, ranging from about 1,000 yards to nearly five miles, the widest part being at the head of the lake. The total bulk of the lake deposits, both in and out of water, in the section between Michigan City and the mouth of Chicago River, is estimated to be 1,747,570,000 cubic yards.

this beach distinguishes it so strikingly from the paucity of life which characterizes the other beaches that a suspicion of a different origin at once arises.

Dr. J. W. Spencer has advanced the view that an uplift at the Niagara outlet is still in progress, and has suggested that the recession of the falls of Niagara past Johnson's Ridge, a ridge standing higher than the remainder of the gorge and situated about a mile north of the Falls, would have caused a temporary partial discharge of the upper lakes, including Lake Erie, into the Mississippi, a discharge which did not stop the outflow by Niagara. He maintains that when Niagara Falls had effected the incision through the Johnson Ridge, the level of Lake Erie fell about 24 feet, reaching a level 17 feet below the Chicago divide, and thus the full flow of the outlet was returned to Niagara. (1.)

The test of the value of Dr. Spencer's ingenious suggestion lies in the occurrence of phenomena immediately south of the ridge, which will demonstrate that the water stood at a level sufficiently high to have caused outflow through the Chicago outlet. Such a stage of water should have left shore markings there as well as on the plain at the head of Lake Michigan. The view that an uplift is still in progress in the vicinity of the Niagara outlet also seems to be sustained by very weak evidence.

Prof. L. E. Cooley has called my attention to rapids at the head of St. Clair River, which he thinks may have a bearing upon the lowering of the lake level a few feet in recent geological times. For several miles the St. Clair River has a fall of about 16 inches per mile, making nearly all the descent of nine feet which is made between Lake Huron and Lake Erie. This rapid portion is stated by Professor Cooley to be cutting glacial drift, and it is his opinion that this drift barrier may have at one time held the lake level even as high as the second beach. The matter is one worthy of investigation, and Professor Cooley has hoped to give it fuller attention. The question of the date of this beach and of its relation to uplifts and barriers must therefore be left open until more substantial evidence is gathered.

THE PRESENT BEACH OF LAKE MICHIGAN.

Dr. Edmund Andrews has discussed the present beach of Lake Michigan in his paper published in an early volume of the Transactions of this Academy, and compared its strength with that of the beaches of Lake Chicago (2). Since this paper is now out of

(1) Proc. A. A. A. S., Brooklyn Meeting, 1894, pp. 242-243.
(2) Trans. Chicago Academy of Sciences, Vol. II, 1870, pp. 1-23.

These do not form continuous lines around the head of the lake, but those in the vicinity of the Chicago University and Jackson Park die out in the marsh, which sets in a short distance south of the park, and those in Lake County, Indiana, die out at their western ends in a sandy plain, which borders Wolf Lake, Lake Calumet, and other small lakes near the State line. This sandy plain stands but 5 to 8 feet above the lake and was apparently an open bay at the time these bar-like features were forming. But it has now become filled with sand, leaving Lake Calumet and the other small lakes as its dwarfed representatives. The beachlets stand only 10 to 12 feet above lake level (except where coated by wind-drifted sand) and are, as noted above, to be referred to the action of the present lake rather than to Lake Chicago.

The outlets of the lake at the time the Third beach was forming appear to have been along three lines; one, that occupied by the mouth of the Chicago River and the south branch of the Chicago River (reversed); a second along the marsh referred to above as leading from the south part of Hyde Park Township northwestward between Englewood and South Lynne, which connects with the south fork of the Chicago River north of the Union Stock Yards; a third leading westward from Riverdale along the Sag outlet. The broadest of these outlets is that leading past Englewood and the Union Stock Yards, and it is possible that the other outlets became nearly closed by sand before this outlet was abandoned.

The altitude of this beach is nowhere more than 20 to 22 feet above the lake (except where wind has drifted sand to higher levels). The outlets could not well have been cut below a level 8 feet above the lake, that being the altitude of the Chicago outlet for several miles below its junction with the present Des Plaines River. The depth of the water in the outlets would, therefore, be 10 to 12 feet or less. As beaches are often built up to a height of 4 or 5 feet above the ordinary level of the lake, it seems probable that the ordinary stage of water was not more than 15 feet above the present stage of Lake Michigan, thus leaving but 7 feet depth of water in the outlet. The Sag outlet reaches nearly 15 feet above the level of Lake Michigan, hence it was probably at all times a minor line of discharge.

As hinted above, the reference of this beach to the same lake which formed the higher beaches is not made with any degree of confidence. Indeed, the abundant life of the waters which formed

4. Coarse sand, not calcareous....................		6 to 12
5. Calcareous loam		3
6. Yellow clay, very calcareous, with leaves imbedded		3
7. Carbonaceous band, not calcareous............		2
8. Yellow calcareous clay, similar to No. 6........		4 to 6
9. Band of carbonaceous material, not calcareous..		2
10. Brown sand, with twigs and peaty material......		8 to 10
11. Water bearing sand and talus-covered slope.....	8	
Height of bluff ....20 to 22 feet.		

The calcareous clays, Nos. 6 and 8, of the last section, and Nos. 6 and 7 of Dr. Marcy's section, contain numerous gasteropod shells. Dr. Marcy has collected a large number of shells from this horizon, among which there are Unios, apparently of several different species, but not specifically identified. Mr. C. T. Simpson has identified nine different genera of mollusks, all of existing species, found in No. 7 of Dr. Marcy's section. Planorbis and Lymnea are very abundant. Prof. D. P. Penhallow has identified two wood specimens, one a new species of Picea (Picea Evanstoni), the other a new oak (Quercus Marcyana) (1). The bone of the deer, found by Dr. Marcy, is a portion of the femur. The writer has found many localities in the sandy portions of this beach, where molluscan shells abound. Nearly every exposure in the sandy district west of the beach, from the main part of the city of Chicago southward to Englewood exhibits them. This beach is, therefore, in striking contrast with the two higher beaches, which contain few remains of aquatic life.

An excellent artificial section across this beach, made by the Fullerton avenue conduit, which leads from the Chicago River eastward to Lake Michigan, across the north part of Chicago, is discussed above. The deposit throughout is mainly sand, but some gravel is encountered. Shells of Unios and other mollusks were noted at frequent intervals throughout nearly the whole width of the deposit. Beneath these beach deposits there is everywhere a pebbly blue-gray clay, apparently an unmodified glacial till. Some of the sewer ditches in Hyde Park, west of Grand boulevard, have reached peat deposits below sand, at a level a few feet above the lake. Wood has often been found in the sand west of this beach in Chicago.

Reference has been made to the beachlets which occupy the interval between the main beach and the present shore of the lake.

(1) Trans Royal Society of Canada, 1891, pp. 39-32, plate II.

depth of several feet. Excavations have shown, however, that till usually sets in at a depth of 10 to 20 feet or less (1).

In Indiana this beach, like the present shore of Lake Michigan, is very sandy. Its dunes, however, seldom reach a greater height than 50 feet, or but one-third to one-quarter the height of dunes on the present shore. Wells along it have occasionally encountered a bed of gravel at the base of the sand at levels, corresponding with the gravelly beaches of the Illinois portion.

One of the best exposures of this beach in the Chicago area is found at the border of the campus of the Northwestern University at Evanston. The following sections, one taken by Dr. Oliver Marcy, of Northwestern University, in 1864, at which time there was a peculiarly good exposure, the other taken by the writer in 1887, at which time there was a less extensive exposure, show a slightly different section. The beach in this interval had suffered an erosion of perhaps 75 or 100 feet.

Section of Beach at Evanston made in 1864.

1. Surface soil, sandy	1½	feet
2. Brown sand and fine gravel	2½	"
3. Coarser gravel, stratified	2½	"
4. Fine sand	2	"
5. Gravel, containing bones of deer	1 1-3	"
6. Fine sand, containing oak logs	1½	"
7. Peat or carbonaceous earth with a marl bed containing molluscan shells in the lower portion or interstratified with the peat	1½	"
8. Gravel	3¼	"
9. Humus soil, with stumps and logs (coniferous)	½	"
10. Yellow clay, laminated and contorted, containing pockets of gravel	3½	"
11. Blue, pebbly clay	2	"
Height of bluff	22	feet

Section of Beach at Evanston in 1887.

	Feet.	Inches.
1. Yellowish-red, iron-stained sand	3 to 5	
2. Band of bog iron ore, granular		4 to 6
3. Gravel, with beds of sand included (the stratification is very irregular in thickness and assorting very imperfect)	5 to 7	

(1) The writer is indebted to Mr. W. C. Holden of the U. S. Geological Survey for many data concerning the distribution of the sand and for access to the accurate maps of the Pleistocene deposits in Chicago, which he has prepared for the Survey.

or other accurate data showing its former extent. The bar is preserved from the Douglas monument southward to Englewood, a distance of four or five miles. This portion consists of a series of overlapping ridges, of which the westernmost or earlier terminate further north than their successors on the east. At the termination of each of these ridges a hook turns out to the west into the bay that was inclosed by the bar. An outlet seems to have been maintained toward the Des Plaines around the southern end of this bar, until it reached Englewood. This may not have been closed until the water level had dropped too low for a discharge to the Des Plaines.

Passing across the outlet marsh from Englewood to South Lynne, a continuation of this beach is found. It leads in a course east of south to South Englewood and thence more easterly across the northwest corner of Calumet Township into Hyde Park, coming to the Illinois Central Railway a short distance north of Pullman. From this point a gravelly ridge is traceable southward past the north border of Lake Calumet, where it dies out in the marsh. A slight beach is formed to the northeast from here on Stony Island, between Lake Calumet and South Chicago. But the main line of this beach is found west of Lake Calumet, running north and south through the west parts of Pullman and Kensington, where it usually has the form of a cut terrace, with banks 10 to 15 feet in height, but changes to a gravelly and sandy beach at the south. This beach comes to the Calumet River at Riverdale, where it connects with the Sag outlet. It reappears on the south side of the river at Dolton and passes thence southeastward into Indiana. Its course in Lake County, Indiana, is eastward through Hessville and Tolleston and Miller. In Porter County it continues with a slight deflection to the north, keeping parallel to the shore of Lake Michigan, and enters LaPorte County near the south edge of Michigan City. A short distance northeast from Michigan City it becomes merged with the dunes of the present shore, and no attempt was made to separate it beyond that city.

The Illinois portion of this beach consists mainly of fine gravel, which is usually well worn, but in places has considerable angular material, as if formed rapidly and subjected for but a brief period to the action of the lake waves. The low district along the Chicago River back of this beach has received quite generally a coating of sand several feet in depth, and the marshy tracts in Hyde Park and Lake Townships are also covered with sand to a

There seems no escape from the conclusion that the lake stood at a lower stage than the level of the second beach before that beach and the bar under discussion were formed.

The Third or Tolleston Beach—This beach receives its name from the village of Tolleston, situated in Northwestern Indiana at the crossing of the Pittsburg, Ft. Wayne and Chicago Railway and the Michigan Central Railway, at a point immediately south of the extreme head of Lake Michigan, and distant only 2½ miles from the head of the lake. It is more complex than either of the higher beaches, and it becomes a matter of no small difficulty to determine what beaches should be included with this lake stage. There are, by actual count, 32 beachlets crossed on a N.-S. line about three miles east of the State line of Illinois and Indiana. The outer line of this series is usually much stronger than the others and stands a few feet higher, and hence is considered the main line. The village of Tolleston and also Hessville and Miller Station, in Indiana, are situated on the outermost or main line.

Many of the beachlets situated between the main line and the shore of Lake Michigan stand only 10 to 12 feet above that lake, and, as shown further on, seem to have been formed after the southeastward outlet was abandoned. This being the case they should not be referred to Lake Chicago. The Third or Tolleston beach, as here described, includes only such beaches and bars as have sufficient elevation above the sill of the Chicago outlet to indicate that they are connected with that outlet—beaches whose elevation is 18 to 25 feet above the level of Lake Michigan.

The portion of the shore of this lake stage, in Lake County, Illinois, is closely associated with that of the higher lake stages, and consists of a gravelly deposit flanking the foot of the cut terrace. In Cook County this beach appears on the grounds of the Northwestern University, in Evanston, and for several miles south it lies near the east border of the bar formed at the next preceding lake stage. From Rose Hill Cemetery southward it is beyond the limits of the bar, but is perhaps itself a bar built out southward into a bay now traversed by Chicago River. It appears to have reached some distance south at an early part of this lake stage, for no well-defined beach appears on the west side of the bay back of it. This bar lies within a mile of the present shore of Lake Michigan and is readily traced as far south as Lincoln Park. The bar is said to have been nearly continuous through the city of Chicago, but it is now obliterated from Lincoln Park southward nearly to the Douglas Monument, and I have been unable to obtain a map

marshy. Notwithstanding the presence of this bar the beach back of it seems to have been acted upon by lake waves with nearly as much vigor as the portion of the beach farther south, which was not thus protected. The bar is much stronger than any part of the beach proper, being 10 to 20 feet in height and nearly one-fourth mile in average breadth—if the sand and gravel on its borders are included.

The second beach is, on the whole, characterized by larger deposition than the upper one, there being throughout much of its extent a line of sandy gravel, 5 to 10 rods or more in width and 2 to 5 feet in height, but it has less conspicuous cut terraces. Its strength is greater in the vicinity of the northern outlet and on the north side of the southern outlet than at points between or outside the outlets. In Illinois and Michigan, however, it is heavily covered with sand, which is probably in large part wind drifted. These accumulations of sand in places reach the height of 30 to 40 feet.

Occasional reports of the discovery of a molluscan shell in this beach have come to my notice, but none have been personally noted. In this respect it is similar to the Upper beach, but in striking contrast with the next lower beach, which is full of fossils.

An excellent exposure of the structure of the bar noted above is found immediately north of Evanston, where the lake is undermining the bar as well as subjacent deposits. The beach sands and gravels rest upon a bed of peat, which was noted by Dr. Andrews and interpreted by him to be the accumulation of a marsh or partially summerged land surface. The peat not only underlies the bar under discussion, but extends eastward across the interval between it and the Third beach. Its level is no higher than that of the Third beach, being but 12 to 15 feet above the present level of Lake Michigan. The peat is in places several feet thick, but at the point where the bar comes out to the lake shore it has a thickness of only 3 to 6 inches. It contains pieces of mangled wood and has been disturbed by waves. Between the peat and the yellowish blue till, which forms the base of the exposure, there is a gravelly sand 6 to 18 inches in thickness, which appears to be a lacustrine deposit. The peat is immediately overlain by about 5 feet of sand, above which there is a bed of coarse gravel. The gravel is thin near the borders of the bar, but has a thickness of 11 to 12 feet beneath the highest part. It is capped by a thin deposit of sand and has layers of sand interstratified with it in its thickest part. The presence of this gravel makes it impossible to suppose that the old land surface has been buried by the drifting of material from the lower beach.

The Second or Calumet Beach.—This beach throughout much of its course in Indiana and for a short distance in Illinois follows the south border of the Calumet River, and because of this close association the name Calumet seems appropriate. It stands about 20 feet lower than the Upper beach, and its course in the Illinois portion of the region traversed by it is indicated on the accompanying map (Plate 3). From the Wisconsin line southward to Chicago River it is closely associated with the Upper beach, wherever that beach remains. From the Chicago to the Des Plaines River it is separated from the Upper beach by an interval of $1\frac{1}{2}$ to 3 miles. The outlet at this stage was at the Des Plaines River, between the villages of Riverside and Summit, and the beach gravels are well developed for a short distance below Summit on the east side of the outlet. The beach leads somewhat directly southeastward from Summit to the north end of Blue Island ridge and then southward along the east side of the ridge, past Washington Heights to the Calumet River, two or three miles east of Blue Island. The Sag outlet had its head at this time in a wide opening between the Calumet and Thornton. Immediately east of Thornton the beach reappears in its customary strength and passes thence eastward across Lake County, Indiana, following the south border of Calumet River at an average distance of perhaps a mile from this stream. In western Porter County, Indiana, near the line of Portage and Westchester Townships, it crosses to the north side of the river, and its course from that point eastward across Porter and northwestern LaPorte Counties is nearly parallel with the present shore of Lake Michigan and distant from it two to three miles. In Michigan it borders the lake even more closely, as far north as observations were carried (to latitude 42 degrees, 30 minutes), being found usually within a mile or two of the lake shore.

This beach extended a conspicuous bar out some distance into the lake above Chicago. Its northern end is found at the lake shore between Wilmette and Evanston, and leads thence southward through the west part of Evanston to Rose Hill Cemetery, and there turns abruptly westward and terminates at the village of Bowmanville, on the east bluff of Chicago River. It is probable that this bar was attached to the old shore at some point farther north than its present terminus, a portion of it having been removed by the encroachments of Lake Michigan. The bay back of this bar had a width of one to four miles and a depth of 15 to 20 feet in its deepest parts. Portions of it were so shallow as to be

found, and this negative evidence strengthens the view that the shells at this pit may be intrusions. Remains of terrestrial life have also been found here. Mr. Haas preserved fragments of the tooth of a mammoth found in the gravel pit at a depth of several feet. These fragments are waterworn, and it seems, therefore, quite probable that they were imbedded during the formation of the beach.

Another gravel pit has been opened in the beach between Salt Creek and LaGrange, in which the excavation extends from the east side of the beach westward nearly to the outer slope. It has a depth of 12 to 14 feet in the deepest part, and exposes a series of beds dipping slightly toward the east. The upper five feet is of brown stained gravel. The lower portion is a fine gravel, with very little stain. In the gravel there are sandy pockets and also thin beds of sand. These sandy portions, in some cases, show a slight effervescence with acid, but are not nearly so calcareous as the sand found at similar depths in glacial deposits.

Interval of Emergence. — After the Glenwood beach was formed the lake appears to have withdrawn from the plain between the beach and the shore of Lake Michigan, in Illinois. How much farther north it withdrew is not accurately determined. Professor Chamberlin recognized evidence of emergence between the formation of this beach and the second beach, in Southeastern Wisconsin. That it withdrew so much in the northern end of the Lake Michigan basin as in the southern seems improbable from the evidence drawn from tilting, it being found by Mr. F. B. Taylor that that portion of the basin has been uplifted more than the southern. Whether this emergence is to be connected with the lake stage, known as the Algonquin, is not yet ascertained, though that seems a probable correlation.

The evidence for this emergence within the Chicago area is found in beds of peaty material that occur beneath gravel of the succeeding lake stage, as long since noted by Dr. Andrews and discussed in his paper cited above. In Wisconsin the evidence is in clay beds, which seem to have been left in a retiring water body, and which are covered by beach deposits of the succeeding lake stage, as pointed out by Prof. Chamberlin in his official report of the Wisconsin Geological Survey. There is need for further study of this interval in the lake history before conclusions of much consequence can be drawn.

A few gravel pits have been opened in this beach. Probably the most extensive is Haas' pit, near Forest Home Cemetery, one mile south of Oak Park. This is opened in the bar described above as leading southward on the east side of the Des Plaines River. The excavation extends from the east side of the bar west past the center and shows beds dipping at various angles, but all towards the east. Some of the beds increase in thickness as they descend, but the lower bed which is mainly sand decreases in thickness in passing from the higher to the lower part of the bar. It appears to be a sand bar upon which the coarser beach deposits are built. The following section was obtained at the south side of this gravel pit and shows the structure at that particular place only, for Mr. Haas states that the material of the same bed may vary greatly in coarseness within the space of a few feet. The dip of the beds, however, is uniformly toward the east, throughout the entire extent of the pit, which covers an area of several acres:

1. Brown-stained gravel, capping summit and slope......	18 to 30	inches
2. Fine gravel, fresh or stained but little...............	24 to 48	"
3. Sand, very thin at top, but increasing toward side of bar	0 to 36	"
4. Fine gravel, increasing like No. 3....................	0 to 48	"
5. Fine gravel, nearly 4 feet in thickness, which passes upward from near the east side of the excavation, assuming a nearly horizontal position beneath the crest of the ridge..	40 to 48	"
6. Sand, thickening toward the higher part of ridge......	6 to 36	"

Mr. Haas reports that shells of the size of unios and also smaller molluscan shells have been found in the bed of sand at the bottom of the pit. The larger shells were thought by him to be unios. A shell, however, which he sent to the writer proved to be the ordinary oyster. This unexpected development raises the question whether this particular shell was in situ at the time it was discovered, if it does not render doubtful the occurrence of any native shells in this bar. Upon visiting the region again and inquiring particularly into the circumstances, there seems little question that the shell was picked up near the base of the pit by some of the workmen, but it was found that there are a few Indian graves on the bar, which extend down nearly to the level of the base of the pit. The shell, therefore, may have been introduced at the time of burial of some brave warrior, or it may have been of more recent introduction. This is apparently the only place along the entire length of the upper beach where molluscan shells have been

west from the railway station, and at an elevation 55 to 60 feet above the lake.

Near the mouth of the Kalamazoo River, in Michigan, there are extensive sand plains standing 90 to 100 feet above the lake, which seem to have been occupied by lake water. The sand deposits extend back nearly to Allegan, on the Kalamazoo, and southward from the Kalamazoo to Paw Paw River, near Hartford, occupying a strip of lowlands back of a moraine that lies near the lake shore. They may have been formed at an earlier stage than the beach under discussion, in a narrow lake held between the ice and the higher land to the east. It seems probable that a small lake would have appeared during the formation of this moraine. In the present stage of investigation it is scarcely legitimate to assume that Lake Chicago reached so high a level there, a level about 40 feet above that of the beaches at the south and west borders of the lake.

There is very little range of altitude shown in the Illinois portion of this beach, the variations being scarcely more than may be attributed to the fluctuations in the lake or to storms. The following presents the railway elevations in succession, from north to south, at points where this beach is crossed:

Table of Altitudes along the Upper or Glenwood Beach.

Station.	Railway.	Elevation. Feet A. T.
Winnetka,	C. & N. W.	658 640
Oak Glen,	C., M. & St. P.	631
Norwood,	C. & N. W.	640 626
Galewood,	C., M. & St. P.	647 623
Maywood,	C., St. P. & K. C.	636
La Grange,	C. B. & Q.	645 627
Border of Moraine,	C. R. I. & P.	658 630
Homewood,	Ill. Cent.	656
Glenwood,	C. & E. I.	636
Dyer, Ind.	L. N. A. & C.	636

In the above table, where two elevations are given, the lower marks the base of the cut terrace and the upper the brow. It is probable that the lake level was but a few feet above the base. In the Illinois portion it may safely be assumed to be 635 to 640 feet above tide or about 53 to 58 feet above the level of the present lake.

Its faintness in this district is probably due, in part, at least, to the protection from wave action occasioned by the bar just described. Upon passing south and crossing Salt Creek, about a mile from the point where the beach fades out, it reappears as a well-defined ridge, composed of sand and gravel, rising from 10 to 12 feet above the border of the plain on the east, and having a breadth of 30 to 40 rods. Following this beach southward, it changes in about a mile to a cut terrace, which is well defined from that point southward to the lake outlet, a short distance south of LaGrange. Its course is through the eastern part of the city of LaGrange, where it is in the form of a cut terrace, with bank 10 to 15 feet in height.

Passing to the west side of the outlet, near Willow Springs, the shore line is found as a cut terrace along the east face of the prominent morainic tract which occupies the interval between the two outlets of the lake. Though mainly a cut terrace the moraine is flanked occasionally by deposits of gravel and sand.

South from the southern, or Sag, outlet the shore is carved on the inner face of the Valparaiso moraine with banks 5 to 20 feet, or more, in height, but with only occasional deposits of gravel and sand. Upon approaching the State line, however, near Glenwood, the shore bears away from the moraine and deposits of gravel and sand are built up to a height of 6 to 12 feet or more. These are sometimes in the form of a single ridge, but not infrequently a series of parallel ridges occur, separated by narrow sags.

The effect of the waves at this lake stage is discernible on the borders of Blue Island till ridge, though the western border is characterized by dunes which conceal to some extent the action of the lake.

Upon passing into Indiana the beach soon becomes sandy, like the shore of the present lake, and dunes with an elevation of 10 to 25 feet are formed throughout much of the course in that State. These dunes, in places, have drifted out for a mile or more beyond the old lake border, reaching elevations somewhat higher than the level of the lake. There are occasional points where gravelly deposits have been found in connection with this shore in Indiana and also in Michigan, but the sand, as a rule, conceals the shore products of the lake. One of the best instances noted of a gravelly beach formed at this stage is at Sawyer, Michigan, a few miles south of St. Joseph. The beach is well exposed by a wagon road leading west from the village, about 100 to 120 rods

minus, perhaps one mile from the point where the terrace departs from the present shore of the lake. From the terminus of this ridge a bar was built out southwestward five or six miles, terminating about a mile east of Chicago River, in the western part of T. 41, R. 13, E. The bar sends out two prominent spurs to the west, a distance of nearly one mile. These probably mark the termini in its earlier stages. The average width of this bar is about one-fourth mile, and it was built up to a height of 10 to 20 feet above the bay back of it. It consists largely of gravel, but has a liberal admixture of sand. The bay back of this bar extended to the valley of the Chicago River and had a width of two to three miles. The northern end finds a narrow extension northward, in Skokie marsh. The site of this old bay is now largely under cultivation, though some portions are still marshy.

The question naturally arises whether this accumulation of gravel and sand was formed by the lake currents and waves, independent of the Chicago River, or was largely formed as a delta from that stream. This deposit is not in the form of a delta built up at the debouchure of the river into the lake, but lies some distance to the east of the river valley. Moreover, to make it still more evident that it was the lake and not the river which contributed the great bulk of the beach deposit, it is found that the river valley above the point where it entered the old lake has very little assorted material, such as would accumulate above a delta.

The beach appears on the west side of the Chicago River, Sec. 19, T. 41, R. 13 E., about a mile northwest from the terminus of the bar. From this point southward to Oak Park the shore is usually a cut terrace (see Fig. 8), with a bank ranging from 6 to 25 feet in height, with occasional deposits of beach gravel and sand along its front. At Oak Park there is an extension of gravel down the east side of the Des Plaines River similar to that of the bar east of the Chicago River, noted above. A ridge or bar 20 to 40 rods in width and 10 feet or more in height extends from Oak Park south about two miles to the south part of Secs. 13 and 14, T. 39, R. 12 E., and there terminates abruptly with a level nearly 20 feet above the plain on its immediate borders.

Passing to the west side of the Des Plaines River, the beach appears about a mile above the southern end of the bar just described and passes in a curving course westward through the south edge of Maywood, in Secs. 14, 22, and 16, T. 39, R. 12 E. This portion of the beach is only two to four feet in height, and at the west it fades out completely.

Fig. 8. Cut terrace formed at upper lake level near Galewood. [Photograph by Gayton A. Douglass.]

The study of the beaches of this glacial lake is not sufficiently complete for me to indicate its precise relations to, or points of connection with, the ice sheet. My study has been carried no farther north than to the line of Illinois and Wisconsin on the west side and to a corresponding latitude on the east side of the lake. Prof. Chamberlin's studies left the precise extent of the higher beaches undetermined. Mr. Taylor's observations have been confined to the northern portion of the basin, and as yet no one has examined the intervening district, with a view to determining the limits of this glacial lake. Probably the most favorable field for investigation will be found on the Wisconsin side, since the extensive deposits of wind-drifted sand on the border of the lake in Michigan make it difficult to determine the extent of water action. The long stretches of high bluff, however, interrupt the beaches so greatly that some difficulty is anticipated in making precise correlations on the Wisconsin side.

The Upper or Glenwood Beach.—This beach receives its name from the village of Glenwood, on the Chicago and Eastern Illinois Railroad, a few miles south of the limits of Chicago. The name has been selected (1) because the beach is especially well developed at that village and (2) because, being near the State line of Indiana and Illinois, the name will be familiar to residents of either State.

In the Illinois portion of Lake Chicago this beach is present, except for a few miles between Waukegan and Winnetka, where the lake shore is now farther west than it was at the time this beach was formed. In Indiana the beach is present throughout the entire extent of the border of Lake Chicago in that State, being nowhere less than two and in places twelve miles back from the shore. In Michigan it is absent for a short distance at the "clay banks," north of New Buffalo, where the present shore stands farther east than the shore of Lake Chicago. It is also absent for the same reason for a few miles near the line of Berrien and Van Buren Counties, north of St. Joseph, Michigan. Tracing in detail the course of this beach is as follows:

From the Wisconsin line southward to South Waukegan, it stands only one to two miles back from the shore of Lake Michigan, and comes out to that shore at the point where the bluff of till sets in south of Waukegan. This bluff of till stands above the lake level as far south as Winnetka. From Winnetka a cut terrace, nearly 20 feet in height, extends south along the face of the east till ridge, noted above, to its ter-

When the ice sheet withdrew from the Ontario basin an eastward outlet was opened by the Mohawk. The Erie and Huron basins were then made tributary to the Mohawk and Hudson, and it is probable that they never afterwards discharged into the Lake Michigan basin. There are, however, complications not yet fully understood, arising in large part from the differential uplifts of the region, which may have resulted in a brief flow of the waters westward along the straits of Mackinac after the ice had withdrawn from the northern end of the Lake Michigan basin.

The working out of the lake history has also brought evidence that the Lake Michigan basin was for a time free from water in its southern end far within the limits of the present shore of the lake. This low stage of the southern end of the basin, it appears, was due not so much to the shrinking of the lake as to lower elevation in the northern latitudes, for at that time the lake apparently stood above its present level at the north end of the basin. The evidence now at hand points to a general northeastward elevatory movement, following more or less closely the retreat of the ice sheet. While, therefore, the retreat of the ice sheet opened low outlets toward the east and thus led to the withdrawal of the water from the southern and western end of the lake basins, the succeeding uplift at the northeast, complicated by conditions which cannot well be entered into here, raised these outlets sufficiently to cause the water to be thrown back and give these lakes their present extent.

The introduction of the name Lake Chicago, for the glacial lake, which was held in the southern end of the Lake Michigan basin, seems convenient, if not necessary, inasmuch as its area was not coincident with that of Lake Michigan, and its outlet was in the reverse direction. It is also in keeping with the custom of students of glacial lakes, who find it advantageous to have a special name for each of the temporary bodies of water in the several basins. The name, Lake Chicago, seems especially pertinent, since the glacial lake extended about as far beyond the present limits of Lake Michigan, in the vicinity of Chicago, as at any part of its border. It is also a name which readily suggests the position of the lake, and it is in keeping with the name which has come into use for the outlet, namely, the Chicago outlet.

The name Lake Chicago is applied provisionally to all the stages at which there was a southwestward outlet, but it is not yet certain whether they were all formed during the occupancy of a portion of the Lake Michigan basin by the ice sheet. This question is discussed at some length further on.

THE GLACIAL LAKE CHICAGO.

During the past ten or twelve years evidence has been gradually accumulating which points to the existence of several glacial lakes held on the north by the ice sheet and having southward discharge over the lowest points in the rims of the basins which they occupied. The area of these lakes would naturally be variable, since a part of the boundary was formed by an oscillating ice sheet. The outlets of the lakes would also be liable to change on account of the covering of certain low outlets in the early stages which were open to discharge in later stages. A change in the extent and the outlets of the lakes, it appears, has also been produced by a warping of the crust or differential uplift in the region they occupy. The complications are therefore great, and as yet the full history is not worked out. Enough is known, however, to make certain that the general direction of retreat of the ice sheet was northeastward. The southern and western portions of the Great Lake basins were, therefore, the first to become free from ice and occupied by glacial lakes.

While the ice sheet was covering the present outlets of Lakes Superior and Michigan, these lakes had no connection with each other, nor with the lakes to the east, and their discharge was southward or southwestward into the Mississippi, from the present heads of these lakes. A small district west of Lake Erie was also occupied by a lake that discharged southwestward to the Wabash. Upon the withdrawal of the ice sheet from the southern peninsula of Michigan and the southern portion of the Lake Huron basin, the lake at the western end of Lake Erie became expanded and a line of discharge was opened eventually from Saginaw Bay across the southern peninsula of Michigan to the Lake Michigan basin, and this being lower than the outlet to the Wabash, that outlet was abandoned. The waters of the Lake Huron basin being held at a somewhat higher level than those of the Lake Michigan basin, the flow of water was from the former to the latter. The glacial lake, which discharged across the southern peninsula of Michigan extended over the district between Lake Huron and Lake Erie, as well as the Lake Erie basin and the low district bordering it on the south and west. It apparently did not extend far into the Ontario basin, as a study of moraines indicates that the ice sheet occupied that basin at the time of this discharge. It thus appears that the Chicago outlet at one time was the line of discharge for an area much larger than the present Lake Michigan basin.

to the surface. (See Figs. 1 and 2.) Below Lemont the bare rock forms much of the floor as far as Joliet. From Joliet to the head of the Illinois perhaps half the floor is covered with deposits of drift and river debris, so that the distance to rock is not known. The remainder is either bare rock or rock with a very thin deposit of coarse river debris, with a liberal supply of bowlders of Canadian derivation. In the Morris basin the rock is largely shale. This has been eroded in places by the current and the hollows filled with sand and gravel. From the Morris basin to the bend of the Illinois the rock floor, mainly sandstone, is generally swept clean. The St. Peter sandstone of this section is of such a texture as to break up rapidly into its constituent grains and these, as fast as they were set free, would have been carried by the strong current down to the lower Illinois, and probably on into the Mississippi. The Lower Illinois has only sand and silt in its bottoms. This section is now in process of silting up, the current being too sluggish to carry away the material brought in from the upper portion of the stream.

In connection with the river debris should be mentioned accumulations of bowlders. The most conspicuous accumulation noted is that on the borders of the Sag outlet, just east of the point where it enters the moraine and northeast of the village of Worth. An area of perhaps a square mile is so thickly strewn that one might almost step from stone to stone over its entire extent. There are, it is estimated, more than 1,000 bowlders per acre. Surface bowlders are not rare in other portions of the old lake bottom, where sand deposits are thin or wanting, there being, perhaps, 100 per square mile on the part of the lake bottom, where till is exposed. There seems, however, to be a tendency to aggregation at the entrance to the old outlets. This feature suggests that floating ice has been influential in their distribution, though there may have been a large number brought by the ice sheet, the head of the outlets being near the inner border of the Valparaiso moraine.

Some very large bowlders have been found along the Drainage Canal, two of which are shown in the accompanying view (Fig. 1). The large ones occur in most abundance where the Valparaiso moraine crosses the outlet. Bowlders are very numerous for a few miles above the junction of the Des Plaines with the Kankakee, both in the lake outlet and the districts south. The cause for their abundance there is not satisfactorily determined. They seldom reach the large size which bowlders in the Valparaiso moraine present.

plished by the lake outlet. Being the outlet from a lake, however, its waters probably carried but little sediment in this portion, a feature which should be weighed in discussing the slight amount of excavation. Whether a stream of nearly clear water could have accomplished the slight excavation here displayed in the course of a few thousand years remains to be determined.

Turning to Niagara River, where the work accomplished in a few thousand years by a clear stream is open to investigation, it is found that the recession of the Horseshoe Fall is due almost wholly to undermining, and that the American Fall, in which there is little undermining, is nearly stationary. The cutting on the rapids above the Falls is also very slow and amounts to but a few feet in average depth.

Professor Cooley has called my attention to the deposits at the head of Lake St. Clair as likely to furnish an index of the amount of sediment transported by the Chicago outlet. A delta, with an area of several square miles, has been built in the head of Lake St. Clair, which must have derived the bulk of its material from southward moving littoral currents along both the borders of Lake Huron. In the lake under discussion littoral currents along the west border would have transported material probably in as great volume as on either shore of Lake Huron, but those on the east and south may have contributed less, for wind drifting there is very effective. It seems legitimate to assume that at least half as much sediment was being transported down the Chicago outlet as is carried by the St. Clair River. The waters of the Chicago outlet would be probably more turbid than the Niagara and less turbid than the St. Clair. Prof. Cooley thinks the contributions of sediment to the outlet through the Des Plaines were of little consequence, for this river has, since the lake waters were withdrawn, made scarcely any filling of the outlet below Riverside, where its delta would naturally accumulate. The accession of larger tributaries below may have rendered the stream slightly more turbid than on the rapids, and the rate of rock excavation would have been correspondingly accelerated.

It should not be inferred that this outlet is entirely free from river debris. Beginning at the upper beach, near Summit, there is for several miles a mass of coarse material, largely limestone blocks, too large to have been transported by the current, covering the bed of the outlet. The Drainage Canal exposes excellent sections of the coarse river debris from Summit to Lemont, there being only limited areas in this interval, where the solid rock comes

Niagara limestone. Its resistance, therefore, may not be markedly greater than that of the beds of glacial drift.

As noted above, the level at which excavation by lake waters began in the section below the great bend of the Illinois, is less than 100 feet above the present stream, since the glacial terraces in which the lake outlet was excavated seldom reach a level 100 feet above the bed of the outlet, while below the mouth of the Sangamon they rise scarcely 50 feet above that level. If the 30 feet of filling estimated by Prof. Cooley be added it seems a liberal estimate to allow 75 feet of average excavation in this lower section of 200 miles. It may not have been more than two-thirds that amount. The width of the outlet in this lower section ranges from two up to about five miles, with an average of perhaps three miles. This excavation is in a loose, easily eroded bed of sand and fine gravel, which had been deposited largely by glacial streams.

Summing up the above estimates, it appears that the outlet has a width ranging from one mile up to about five miles, and a depth ranging from 20 feet up to 70 feet. Its length from Summit to the mouth of the Illinois is 300 miles. The excavation is probably not less than three cubic miles. With the exception of about fifteen miles between Lemont and Joliet and forty miles between Morris and Peru, where rock strata have been eroded, the excavation is almost entirely in beds of drift. The width varies with the resistance to erosion, being least in the section where the Niagara limestone was eroded and greatest where there were only drift beds to remove, while in the sandstone the channel is of intermediate breadth. The breadth is also to some degree dependent upon the slope of the bed, being narrower in the portions, with rapid fall, than in portions having a low rate of descent.

Throughout the entire length of the outlet the bluffs are steep, like a river bank, and deposits made by side streams on the edge of the valley are very meager, a feature which indicates that the stream had great volume, probably filling the channel from bluff to bluff, and a current sufficiently strong to carry away nearly all the detritus brought into it by the side streams.

The rapids between Romeo and Joliet occur in a section where the limestone is friable, and it is thought by Professor Cooley that the friability is such that falls could not have been maintained, or even established. The removal of this, the main barrier in the course of the outlet, it is estimated, would require the excavation of a channel in rock only about 20 miles in length and 25 to 75 feet in depth. Of this excavation scarcely one-tenth part was accom-

Fig. 7. Channels in bed of Chicago outlet, near Lemont, apparently due to water abrasion rather than ice. [Photograph by Chicago Drainage Commission.]

not markedly greater than in the portion above Joliet. The portion above Joliet is cut to a slight depth into the Niagara limestone, which there underlies the glacial gravel. The excavation in limestone, however, amounts to not more than one-fourth the size of the channel, for the limestone seldom rises more than 40 feet above the bed of the lake outlet and in many places its surface comes down nearly to the level of the valley floor. Below Joliet there was even less excavation in the rock than above. It is estimated that the rock excavation here does not exceed ten per cent. of the total cutting.

In the low tract at the head of the Illinois (the Morris basin) the depth of excavation by the outlet is very slight, averaging probably less than 20 feet in the ten miles between the head of the Illinois and Morris. The plain appears to have descended nearly to the 520-foot contour on the borders of the river before modified at all by lake or stream action. A low bluff formed on the north border of the basin has a height of 15 to 20 feet. On the south border there is no bluff, that side of the basin being heavily coated with sand deposits. These deposits may perhaps have been laid down in part at the time the lake waters were forming the outlet, but they are probably largely of earlier date. In this basin the lake outlet had an average width of four or five miles.

In the section of the Illinois, immediately below (west from) this basin, erosion, prior to the opening of the Chicago outlet, may have brought the level of the valley bottom down to that of the upper beach line of the basin, 550 to 560 feet above tide. The bed of the Chicago outlet is nearly 500 feet, thus leaving about 60 feet depth of erosion. Passing westward the broad bed of the Chicago outlet declines nearly 60 feet in the forty miles between the west border of the basin, just mentioned, and the bend of the Illinois near Hennepin. Whether the valley had the same gradient at the time the accession of lake waters occurred is not known, but it could not have been greatly different, for the glacial terrace just above Hennepin stands about 30 feet lower than the beach lines of the Morris basin, and this terrace was, in all probability, eroded the remaining 30 to 40 feet necessary to give a similar gradient.

The width of the outlet between Morris and Hennepin averages about 1½ miles. The excavation is largely in a soft sandstone, there being nearly continuous rock bluffs to a height of 60 to 75 feet above the level of the bed of the outlet. This sandstone presents much less resistance to stream action than the firm

Plaines and other tributaries entering the basin farther east, thus permitting the water to issue at the western end of the basin, unburdened with glacial material. The stream discharging westward from this basin would therefore have a tendency to deepen the new valley opened across the Marseilles moraine, and in all probability would have extended its excavation at least through the new portion of the valley to Hennepin, there being in that section a gradient of several inches per mile and possibly at first a gradient of several feet. It seems not improbable, also, that some excavation was accomplished by the glacial floods in their passage over the terraces in the lower portion of the Illinois Valley, the advantages for erosion being as good for these floods as for the later ones fed by Lake Chicago.

It is also necessary to estimate the amount of filling which the lower course of the outlet has received since the lake waters were withdrawn. Concerning this filling, Prof. L. E. Cooley has made some investigation and concludes that it will average about 30 feet from Peru to the mouth of the Illinois. (1.)

In the Des Plaines Valley the erosion of the Valparaiso moraine and of the terraces outside of it was probably very largely effected by the lake waters. An examination of this portion of the outlet will therefore be likely to afford a fair understanding of the size of the channel which it formed.

Turning to the topographic maps, it appears that the bed of the lake outlet declines from about 590 feet A. T. at Lemont, in the midst of the Valparaiso moraine, to scarcely 500 feet at the head of the Illinois, or 90 feet in a distance of 25 miles. Of this fall 76 feet is made in a little less than ten miles from Romeo to Joliet pool. The glacial terraces which border the outlet decline from about 630 feet to 570 feet between Lemont and the head of the Illinois. This deepening of the channel is shown by the maps to be somewhat irregular, ranging from 40 feet to about 70 feet, but an average erosion of 50 feet may be assumed. This deepening embraces not only the work at the time the upper beach was forming, but also that carried on during the formation of the middle and third beaches, or down to the time of the final abandonment of the lake outlet. The channel above Joliet has a breadth of one to one and a half miles, averaging perhaps one and a quarter miles. Between Joliet and the head of the Illinois several island-like remnants of the glacial terraces remain in the midst of the channel, making it more difficult to estimate the breadth, but it is

[1] Communicated to the writer,

Fig. 6. Striated ledge in bottom of Chicago Drainage Canal near Willow Springs. [Photograph by Chicago Drainage Commission.]

which covers nearly all of Cook County and the immediate borders of the Chicago outlet along the Des Plaines River. This map has not been published, being merely a study map. The topographic work carried on by the U. S. Geological Survey in this region is largely published. The peculiar features of the upper portion of the outlet are brought out in an effective manner by the following sheets, viz: The Chicago, Riverside, Calumet, Des Plaines, Joliet, Wilmington, Morris, Ottawa, Marseilles, La Salle, Hennepin and Lacon sheets. These sheets cover something over 100 miles of the former lake outlet or nearly one-third the distance from the head of the outlet to the Mississippi. The remainder of the outlet is shown in Professor Rolfe's map sheets, yet unpublished. The reduced contour map (Plate 2) accompanying this paper is based upon these several surveys. It serves to indicate the comparative size of the valleys occupied by the outlet and of the main tributaries of the Illinois. But to fully appreciate the features produced by the outlet, reference should be made to the large scale maps just mentioned.

In the interpretation of these features from the maps, care must be exercised in determining the condition of the valley at the time the outlet first became operative. The portion of the Illinois below Hennepin, it will be observed, is a preglacial valley, which is only partially filled by the glacial deposits. This filling is preserved in terraces along the borders of the valley. The glacial terraces seldom rise to a height of more than 100 feet, and in the lower 100 miles their average height scarcely exceeds 50 feet above the present stream. In the portion of the valley above Hennepin the stream is mainly in a glacial or postglacial course, or the two combined, but even here there are complications which make it no easy matter to determine the amount of erosion attributable to the outlet. Before the accession of the lake waters this valley was the line of discharge for streams issuing from the ice sheet, as possibly of interglacial streams, some evidence of which has been gathered by Professor Chamberlin. Although the streams were generally so heavily charged with detritus as to build up rather than erode their beds for some distance below the point of emergence from the ice sheet, it seems scarcely probable that filling would have exceeded erosion throughout the entire length of the Des Plaines and Illinois Valleys. The basin at the head of the Illinois, as noted above, was apparently occupied by a lake at the Valparaiso stage of glaciation and this would have received the greater part of the detritus borne down by the glacial floods on the Des

Davis.—Professor W. M. Davis has published a description of the Chicago outlet in the Popular Science Monthly (2). His paper was based upon a personal inspection of the channel with the topographic maps in hand, and is a remarkably clear discussion of the features.

Guthrie. —Mr. Ossian Guthrie, of Chicago, has contributed several newspaper articles and has published two or more pamphlets within the past few years which contain popular accounts of local features in the region under discussion and which have served to stimulate interest in its geological history. Having been a resident of the city for about 50 years and an enthusiastic student of natural features he is in possession of a fund of information which it is to be hoped will be placed on record in suitable form for reference.

THE CHICAGO OUTLET.

The name "Chicago Outlet" has come into use by geologists and engineers without announcement or conference among writers, to designate the line of southwestward discharge from the basin of Lake Michigan across the low divides near Chicago and thence down the Des Plaines and Illinois to the Mississippi. It may appropriately embrace both the points of discharge from the lake to the Des Plaines, namely, the one entering at Summit and the one at Sag Bridge.

When the lake was occupying the highest beach the north or main outlet was entered about three miles southwest of Summit; when occupying the second beach the outlet was entered at Summit; when occupying the third beach the point of entrance appears to have been transferred eastward nearly to the present shore of Lake Michigan, as explained below. Similarly the southern outlet was lengthened eastward with the lowering of the lake. The point of entrance at the time of the highest beach being about five miles east of Sag Bridge, at the time of the second beach near Blue Island, and at the time of the third beach at Riverdale. This relationship of the several beaches to the outlets and the eastward lengthening of the outlets may be readily understood by a glance at the accompanying map. (Plate 3.)

There have been several surveys which have contributed contour maps of portions of the Chicago outlet and the plain covered by the lake in the vicinity of Chicago. The Chicago Drainage Commission have prepared an excellent map with five-foot contours

[2] The Ancient Outlet of Michigan, by Prof. W. M. Davis. Popular Science Monthly, December, 1894, pp. 218-229.

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